PATENT COOPERATION T ATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 04 February 2000 (04.02.00)	
International application No. PCT/GB99/01765	**Applicant's or agent's file reference** A25547/WO
International filing date (day/month/year) 04 June 1999 (04.06.99)	**Priority date** (day/month/year) 05 June 1998 (05.06.98)
Applicant BRISCOE, Robert, John et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

20 December 1999 (20.12.99)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Jean-Marc Vivet
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
A25547/WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/ 01765	04/06/1999	05/06/1998

Applicant

BRITISH TELECOMMUNICATIONS plc et al.

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed. unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   ACCOUNTING IN A COMMUNICATIONS NETWORK

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.

   [X] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
CT/GB 99/01765

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L12/14 H04L12/56 H04Q3/00 H04L12/24 H04M15/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L H04Q H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 05749 A (WULKAN ITZHAK ;BARAK GIDEON (IL); CALL MANAGE LTD (IL)) 13 February 1997 (1997-02-13)	1,4, 26-28,33
A	abstract page 1, line 9-29 page 5, line 15 -page 7, line 30 page 11, line 13-28 page 22, line 12 -page 23, line 30 page 25, line 26 -page 26, line 32 figures 7-9,11	13,14,16
X	EP 0 622 941 A (TAMURA ELECTRIC WORKS LTD ;KOKUSAI DENSHIN DENWA CO LTD (JP)) 2 November 1994 (1994-11-02)	1,4, 24-28, 31,36
A	abstract column 1, line 1 -column 4, line 14	29

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 1999	25/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lievens, K

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Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 647 055 A (AT & T CORP) 5 April 1995 (1995-04-05) abstract column 1, line 1 -column 2, line 21	1,4, 26-28,31
X	SIETMANN R: "TARIFMODELLE GEGEN STAUS AUF DER INFOBAHN" FUNKSCHAU, vol. 71, no. 8, 3 April 1998 (1998-04-03), pages 28-30, XP000779238 page 28, left-hand column, line 1 -right-hand column, line 40	32
X	MURPHY J ET AL: "DISTRIBUTED PRICING FOR EMBEDDED ATM NETWORKS" FUNDAMENTAL ROLE OF TELETRAFFIC IN THE EVOLUTION OF TELECOMMUNICATI NETWORKS, PROCEEDINGS OF THE 14TH. INTERNATIONAL TELETRAFFIC CONGRESS - ITC 1 JUAN-LEES-PINS, JUNE 6 - 10, 1994, no. 1B, 6 June 1994 (1994-06-06), pages 1053-1063, XP000593354 LABETOULLE J;ROBERTS J W (EDS) ISBN: 0-444-82031-0	32
A	page 1054, line 17 -page 1055, line 10 page 1057, line 6-14 page 1060, line 9 -page 1061, line 15	1,4,6,7, 26,31
X	WO 95 27385 A (TELCO SYSTEMS INC) 12 October 1995 (1995-10-12) abstract page 1, line 1 -page 6, line 25 page 7, line 26 -page 14, line 29 page 27, line 8 -page 28, line 14	17
A	DAVID CLARK: "A model for cost allocation and pricing in the Internet" MIT WORKSHOP ON INTERNET ECONOMICS, March 1995 (1995-03), XP002102708 http://www.press.umich.edu/jep/works/ClarkModel.html cited in the application page 2, line 11-33 page 8, line 16 -page 10, line 31 page 15, line 21 -page 16, line 15	6

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International Application No
PCT/GB 99/01765

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 02828 A (BELLSOUTH CORP) 22 January 1998 (1998-01-22) abstract page 6, line 4 -page 13, line 8 page 14, line 8 -page 15, line 2 page 19, line 17 -page 21, line 16 page 23, line 26 -page 25, line 8 page 27, line 18 -page 30, line 6 page 32, line 17 -page 33, line 1 figures 2,3	1,18,26, 29
A	APPLETON J: "PERFORMANCE RELATED ISSUES CONCERNING THE CONTRACT BETWEEN NETWORK AND CUSTOMER IN ATM NETWORKS" TELECOMMUNICATION ACCESS NETWORKS: TECHNOLOGY AND SERVICE TRENDS PROCEEDINGS OF THE IX INTERNATIONAL SYMPOSIUM ON SUBSCRIBER LOOPS AND SERVICES (ISSLS), AMSTERDAM, APR. 22 - 26, 1991, no. SYMP. 9, 22 April 1991 (1991-04-22), pages 182-188, XP000516590 LEMSTRA W ISBN: 0-444-89050-5 page 182, line 1 -page 183, line 13 page 185, line 21 -page 187, line 25	19
A	NISHIBE Y ET AL: "DISTRIBUTED CHANNEL ALLOCATION IN ATM NETWORKS" PROCEEDINGS OF THE GLOBAL TELECOMMUNICATIONS CONFERENCE (GLOBECOM), HOUSTON, NOV. 29 - DEC. 2, 1993, vol. 1, 29 November 1993 (1993-11-29), pages 417-423, XP000428091 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS page 417, left-hand column, line 1 -page 418, right-hand column, line 29	18,19,29

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/01765

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9705749 A	13-02-1997	US 5764741 A	09-06-1998
		US 5799072 A	25-08-1998
		AU 705826 B	03-06-1999
		AU 6368396 A	26-02-1997
		CA 2227569 A	13-02-1997
		EP 0865706 A	23-09-1998
		US 5862203 A	19-01-1999
EP 0622941 A	02-11-1994	JP 2852845 B	03-02-1999
		JP 6311261 A	04-11-1994
		US 5448628 A	05-09-1995
EP 0647055 A	05-04-1995	JP 7177264 A	14-07-1995
WO 9527385 A	12-10-1995	US 5570345 A	29-10-1996
		US 5526362 A	11-06-1996
WO 9802828 A	22-01-1998	AU 3660997 A	09-02-1998
		CA 2259367 A	22-01-1998
		EP 0913050 A	06-05-1999

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PATENT COOPERATION TREATY

REC'D 22 AUG 2000
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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
A25547/WO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01765	04/06/1999	05/06/1998
International Patent Classification (IPC) or national classification and IPC H04L12/00		
Applicant BRITISH TELECOMMUNICATIONS plc et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 13 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
20/12/1999	18.08.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Agreda Labrador, A Telephone No. +49 89 2399 8263

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/01765

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-32 as originally filed

Claims, No.:

1-35 as received on 29/05/2000 with letter of 26/05/2000

Drawings, sheets:

1/14-14/14 as originally filed

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 24, 25, 27, 28, 35.

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   ☐ restricted the claims.

   ☐ paid additional fees.

   ☐ paid additional fees under protest.

   ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

   see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

   ☒ all parts.

   ☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-23, 26, 29-35
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-23, 26, 29-35
Industrial applicability (IA)	Yes:	Claims	1-23, 26, 29-35
	No:	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Reference is made to the following documents, cited in the search report:

D1: WO 97 05749 A (WULKAN ITZHAK; BARAK GIDEON (IL); CALL MANAGE LTD (IL)) 13 February 1997

D2: EP-A-0 622 941 (TAMURA ELECTRIC WORKS LTD; KOKUSAI DENSHIN DENWA CO LTD (JP)) 2 November 1994

D3: EP-A-0 647 055 (AT & T CORP) 5 April 1995

D4: DAVID CLARK: 'A model for cost allocation and pricing in the Internet' MIT WORKSHOP ON INTERNET ECONOMICS, March 1995, XP002102708 http://www.press.umich.edu/jep/works/Clark Model.html cited in the application

D5: NISHIBE Y ET AL: 'DISTRIBUTED CHANNEL ALLOCATION IN ATM NETWORKS' PROCEEDINGS OF THE GLOBAL TELECOMMUNICATIONS CONFERENCE (GLOBECOM), HOUSTON, NOV. 29 - DEC. 2, 1993, vol. 1, 29 November 1993, pages 417-423, XP000428091 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

D6: APPLETON J: 'PERFORMANCE RELATED ISSUES CONCERNING THE CONTRACT BETWEEN NETWORK AND CUSTOMER IN ATM NETWORKS' TELECOMMUNICATION ACCESS NETWORKS: TECHNOLOGY AND SERVICE TRENDS PROCEEDINGS OF THE IX INTERNATIONAL SYMPOSIUM ON SUBSCRIBER LOOPS AND SERVICES (ISSLS), AMSTERDAM, APR. 22-26, 1991, SYMP. 9, 22 April 1991, pages 182-188, XP000516590 LEMSTRA W ISBN: 0-444-89050-5

D7: WO 95 27385 A (TELCO SYSTEMS INC) 12 October 1995

Re Item III: Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. No opinion can be formed on the novelty, inventive step and industrial applicability of present claims 24, 25, 27, 28 and 35 (Article 34(4)(a)(ii) PCT, see also PCT Guidelines C-VI-5.11) because none of these claims specify any technical feature required for the definition of the invention (Article 6 PCT).

   For further information, see Item VIII of the present report.

Re Item IV: Lack of unity of invention

1. See Item VIII.2.

Re Item V: Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Although it has been particularly difficult to assess the scope of the claims in view of the serious clarity problems therein (see Item VIII of the present report), the following comments could be made:

1. Independent claim 1 does not meet the requirements of Articles 33(1) and (3) PCT because its subject-matter is not based on an inventive step.

   The document D1 is regarded as being the closest prior art to the subject-matter of claim 1 and this document shows the following features thereof (applying the terminology of present claim 1 and references in parenthesis relating to D1):

   A method of operating a communications network (page 11, lines 27-28) including distributing a tariff for the use of the communications network to a multiplicity of customer terminals connected to the communications network via a communications network (see page 22, lines 30-32) and
   calculating using the said tariff a charge for use by the customer terminal of the network to which the tariff applies (see page 22, lines 31-32).

   This is a large part of the wording of claim 1. The only distinguishing features are:

- the communications network supports a packet-based internetworking protocol;
- the tariff is distributed via the same communications network.

   The first distinguishing feature is related with the application of the method of D1 to the Internet. However, the Internet is very well known to a skilled person and it is immediate to implement this solution, especially having regard to the fact that in D1, **the tariff is distributed to the customer terminals via the Internet.**

Concerning the second distinguishing feature, it is not appropriate to send the tariff data via the PSTN because this network was designed to carry voice communications. If the network concerned were able to carry digital data, it would be inefficient to use another network to distribute the tariff data. Moreover, it is obvious to use the Internet to distribute the tariff data because this solution is already disclosed in D1.

Therefore, the subject-matter of claim 1 is not based on an inventive step (Articles 33(1) and (3) PCT).

2. Furthermore, the subject-matter of claim 1 is also rendered obvious by the disclosures of documents D2 and D3 because these documents, which are related to billing in a communications network, also disclose most of the essential technical features of claim 1 (see especially D2, abstract and summary of the invention and D3, abstract). Therefore, an inventive step (Articles 33(1) and (3) PCT) of claim 1 cannot be acknowledged with respect to any of these documents.

3. Independent method claims 14, 16, 18, 23 and 32 refer to substantially the subject-matter of claim 1 and their additional features do not add anything of inventive significance (Articles 33(1) and (3) PCT), being either obviously derivable from D1 in combination with D4 or common design measures for a person skilled in the art. The skilled person would surely consider the disclosure of D4, taking into account that the billing method of D1 can be applied to the Internet and D4 is an IETF draft relating to pricing in Internet.

a) The additional features of claim 14 are derivable from D4:
- operating a plurality of services on the network (Introduction, paragraph 4);
- selectively varying a respective tariff depending on an operational condition of a respective service (Pricing the Internet service, paragraph 5).

b) Concerning the additional features of claim 16:
- a plurality of different tariffs: derivable from D4 (Introduction, paragraphs 3 and 4 and Pricing the Internet service, paragraph 1);
- measuring the loading of network resources and varying the tariffs in dependence upon the loading of the network resources: derivable from D4 (Introduction,

paragraph 2 and Pricing the Internet service, paragraph 5);
- the different tariffs having different respective volatilities: so vague and general that it can be read onto D1 (page 16, lines 23-24).

c) Concerning the additional features of claim 18:
- making a payment: obvious objective of any of the prior art documents;
- sampling part only of the traffic between the users and the network: trivial feature disclosed in D5 (2.2 Monitoring Channel Utilizations, lines 1-3) and also derivable from D4 (see especially Pricing the Internet Service, paragraph 7 and Pricing expected capacity, paragraphs 1-3);
- for the sampled traffic comparing any payments made by users and the payment due according to the traffic: derivable from D4 (see especially Pricing the Internet Service, paragraph 7 and Pricing expected capacity, paragraphs 1-3).

d) With respect to claim 23, the additional feature of distributing the tariff by communicating separately a formula for calculation of network usage charges and coefficients for use in the said formula would be surely considered by a skilled person in his obvious aim to improve the efficiency of the system (the formula is not normally updated so often as the coefficients are).

e) The additional features of claim 32 are, as explained in Item V.3(a), derivable from D4 (Introduction, paragraph 2 and Pricing the Internet service, paragraph 5).

4. Independent claim 19 does not meet the requirements of Articles 33(1) and (3) PCT because its subject-matter is not based on an inventive step.

The document D6 is regarded as being the closest prior art to the subject-matter of claim 19 and this document shows the following features thereof:

A method of operating a communications network comprising:
establishing contracts between network users and a network operator and storing user contract data (page 182, Introduction, lines 1-2);
sampling the traffic from a user on the network (page 183, lines 8-9);
comparing sampled traffic with traffic contracted for by the user (page 183, lines 9- 11);

This is a large part of the wording of present claim 19, the subject-matter of which therefore differs from the state of the art given by D6 in that:

a) only part of the traffic is sampled;
b) also the incoming traffic is sampled;
c) the user status is amended when a discrepancy between the sample parameters and the contracted parameters is detected.

The distinguishing feature a) is related to a simple-to-implement method of sampling a channel with little computational processing, an obvious desire for the skilled person. D5 discloses this feature (2.2 Monitoring Channel Utilizations, lines 1-3).
The other two distinguishing features add nothing of inventiveness to the disclosure of D6 because sampling also the incoming traffic is a trivial measure and amending the user status is a method of punishing the unscrupulous users and analogous methods such as discarding cells or punitive charging are disclosed in D6 (page 183, lines 9-11 and page 187, line 14).

The claim does therefore not meet the requirements of Articles 33(1) and (3) PCT.

6. Independent method claim 29 refers to substantially the subject-matter of claim 19. The additional features of measuring network usage at a customer terminal and communicating network usage from the customer terminal to the network operator are equivalent to sending the traffic characteristics of a connection to the network by a customer wishing to establish a connection, as disclosed in D6 (page 183, lines 1-5). Consequently, its additional features do not add anything of inventive significance (Articles 33(1) and (3) PCT).

7. The features of independent claim 31 are a combination of those of claims 1 and 29 and, as explained above (see V.1 and V.6) do not meet the requirements of Articles 33(1) and (3) PCT regarding inventive step.

8. The subject-matter of independent apparatus claim 26 corresponds essentially to the subject-matter of method claim 1. In fact, the technical features of claim 26 are derivable from the same paragraph of the prior art documents cited in V.1.

Therefore, the subject-matter of claim 26 is not based on an inventive step and this claim fails to meet the requirements of Articles 33(1) and (3) PCT.

9. The additional features of dependent claims 2-13, 15, 20-23, 30 and 33- 35 do not add anything of inventive significance (Articles 33(1) and (3) PCT) to the independent claims on which they depend, being either obviously derivable from D1 or D4 or common design measures for a person skilled in the art:

- claims 2-3, 5, 7-12, 30 and 35: trivial features or common measures in a communications network;
- claim 4: disclosed in D1 (abstract, lines 7-8; page 5, lines 15-17);
- claim 6: derivable from D4 (Introduction, paragraph 2 and Pricing the Internet service, paragraph 5);
- claim 13: derivable from D1 (page 11, lines 13-26) and D4 (Introduction, paragraph 2 and Pricing the Internet service, paragraph 5);
- claim 15: derivable from D1 (page 11, lines 13-26 and page 16, lines 23-24);
- claims 20-22: derivable from D4 (sections 4 Pricing the Internet Service and 4.1 Pricing expected capacity, paragraphs 1-3) and D6 (page 187, line 14);
- claim 23: derivable from D1 (page 11, lines 27-28);
- claim 33: disclosed in D1 (page 6, lines 14-22);
- claim 34: derivable from D4 (sections 4 Pricing the Internet Service and 4.1 Pricing expected capacity, paragraphs 1-3).

10. Claim 17 does not meet the requirements of Articles 33(1) and (3) PCT with respect to inventive step because all its features are derivable from D7 (abstract; pages 4-6 and 7-14).

With respect to this claim, see also sections IV and VIII of the present report.

Re Item VII: Certain defects in the international application

1. The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art (documents D1, D6 or D7) being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included

in the characterising part (Rule 6.3(b)(ii) PCT).

2. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

3. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1 and D4-D7 is not mentioned in the description, nor are these documents identified therein.

4. The description on pages 1-5 should have been adapted to the amended set of claims (Rule 5.1(a)(iii) PCT).

Re Item VIII: Certain observations on the international application

1. The **plurality of independent claims** in the method category (claims 1, 14, 16, 18, 19, 23, 27, 29, 31 and 32), comprising in part varying combinations of features and in part various different formulations and terminology, renders the set of claims as a whole not clear and concise.

   The same statement is valid for the corresponding independent apparatus claims 24, 28 and 35 referring to a network and 25-26 referring to a customer terminal.

   Moreover, the **total lack of consistency** between the cited independent claims in defining the essential features of the invention **makes it impossible for a third party to determine the scope of protection sought**.

   Hence, claims 1, 14, 16, 18, 19, 23-29, 31-32 and 35 do not meet the requirements of Article 6 PCT.

2. Independent claim 17 does not contain the same essential technical features of the invention (except that of a communications network) when compared with the rest of the independent claims and, as a result, as well as rendering the set of claims as a whole unclear, relates a priori to a different concept thus offending the requirements for **unity of invention** (Rule 13.1 PCT).

3. Claims 24, 25, 27, 28 and 35 do not specify any technical feature needed to define the invention and, as a result, do not meet the requirements of Article 6 PCT and Rule 6.3(a) PCT. Hence, they should have been deleted or redrafted to overcome the following objections and to include all the essential features of the invention.

a) Independent claims 27 and 28 contain references to the description and the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

b) Apparatus claims 24, 25 and 35 have to be considered as independent claims.

It should be noted that a claim may contain a reference to another claim without necessarily being a dependent claim (see PCT Guidelines, C-III-3.8). In particular, a claim referring to a claim of another category (such as an apparatus claim referring to a method claim) is, per definition, an independent claim.

The fact that claims 24, 25 and 35 refer to a method claim simply means that the apparatus is suitable for putting into practice said method, without necessarily defining the means which are required (see also PCT Guidelines, C-III-4.8).

Further, even if the reference to the method claim is retained, **claims 24, 25 and 35 should explicitly contain all the essential features necessary to the definition of the invention** (Article 6 PCT taken in combination with Rule 6.3(b) PCT) and should not attempt to substitute them by a reference back to the method claim.

In principle, an independent claim should be understandable **per se** without needing to refer to another claim.

4. Some of the features in the independent apparatus claim 26 relate to activities, i.e. steps of a method (e.g. "...a network interface which in use receives...") rather than clearly defining the apparatus in terms of apparatus technical features. The category of this claim is therefore not clear (Article 6 PCT).

This deficiency could have been overcome by using the "means being adapted for..." type of formulation (e.g. "...a network interface adapted for receiving...").

5. Dependent claim 33 does not meet the requirements of Article 6 PCT because its category is not clear. In fact, the claim depends on "any one of the preceding claims" and there are both method and apparatus preceding claims.

6. The term "tariff algorithm" in claim 2 lacks an antecedent (Article 6 PCT).

CLAIMS

1. A method of operating a communications network supporting a packet-based internetworking protocol including

distributing a tariff for the use of the communications network supporting a packet-based internetworking protocol via the said communications network to a multiplicity of customer terminals connected to the communications network, and

calculating using the said tariff a charge for use by the customer terminal of the communications network.

2. A method according to claim 1, in which the step of distributing the tariff includes steps of communicating separately a formula for calculation of network usage charges, and coefficients for use in the said formula.

3. A method according to claim 1 or 2, in which the tariff is distributed to customer terminals by multicasting.

4. A method according to any one of the preceding claims, including a further step of distributing to the customer terminals a revised tariff.

5. A method according to claim 4 , in which the step of distributing a revised tariff comprises communicating revised coefficients for use in the formula previously distributed to the customer terminals.

6. A method according to claim 4 or 5, including detecting loading of network resources and determining a revised tariff in dependence upon the results of the said step of detecting loading.

7. A method according to claim 6, in which the steps of detecting loading and determining a revised tariff are carried out automatically by a network management platform.

8. A method according to anyone of the preceding claims including communicating to a customer terminal data identifying a first predetermined communications channel, and at the customer terminal subsequently monitoring the said communications channel for communications relating to the said tariff.

9. A method according to claim 8, including communicating on the said first communications channel data identifying one or more further communications channels, and the customer terminal subsequently monitors in addition the or each further channel.

10. A method according to claim 9, including introducing a new communications channel and identifying the said new communications channel on a communications channel previously identified to the customer terminal depending on loading of the said previously identified communications channel.

11. A method according to any one of the preceding claims including communicating encrypted tariff data to the customer terminal, and decrypting the said tariff data within a secure module located at the customer terminal.

12. A method according to claim 11 including communicating different tariff data on a plurality of different communication channels and providing at a customer terminal a key specific to tariff data on one of the plurality of communication channels.

13. A method according to any one of the preceding claims, including operating a plurality of different services on the communications network,

communicating different tariffs for different respective services to the multiplicity of customer terminals, and selectively varying a respective tariff depending on an operational condition of the respective service.

14. A method of operating a communications network comprising:

operating a plurality of different services on the network;

communicating tariffs for the different services to a multiplicity of customer terminals via a common tariff distribution mechanism;

and selectively varying a respective tariff depending on an operational condition of a respective service.

15. A method according to any one of the preceding claims, including communicating different tariffs having different respective volatilties to different respective ones of the multiplicity of customer terminals.

16. A method of operating a communications network, including

calculating for each of a multiplicity of customers, using a selected one of a plurality of different tariffs, charges for the use of network resources by a respective customer terminal attached to the network,

measuring the loading of network resources, and

varying one or more of the plurality of different tariffs in dependence upon the loading of the network resources, and in which different ones of the plurality of different tariffs have different respective volatilities.

17. A method of operating a communications network in which at a point of access to the network a single blocking test only is applied to traffic entering the network .

18. A method of operating a communications network comprising:

a) communicating tariff data to a user terminal connected to the network;

b) calculating at the user terminal using the tariff data a charge for traffic communicated between the network and the terminal and making a payment;

c) sampling part only of the traffic communicated between users and the network and for the sampled traffic comparing any payments made by users and the payment due according to the tariff .

19. A method of operating a communications network comprising;

a) establishing contracts between network users and a network operator and storing user contract data;

b) sampling part only of the traffic to or from a user on the network;

c) comparing sampled traffic with traffic contracted for by the user; and

d) amending the user status when a discrepancy between the sampled parameters and the contracted parameters is detected.

20. A method according to claim 19, in which the step of establishing contracts between network users and the network operator includes making an advance payment for network usage.

21. A method according to claim 19 or 20, in which the step of amending the user status includes fining the user.

22. A method according to claim 19, in which in step (a) the user transfers a deposit to the network operator, which deposit is debited in step (d) when the discrepancy between the sampled parameters and the contracted parameters is detected.

23. A method of operating a communications network including

distributing a tariff via the communications network to a multiplicity of customer terminals connected to the communications network, and

calculating using the said tariff a charge for use by the customer terminal of the communications network,

and in which the step of distributing the tariff includes steps of communicating separately a formula for calculation of network usage charges, and coefficients for use in the said formula.

24. A communications network arranged to operate by a method according to any one of the preceding claims.

25. A customer terminal adapted for use in a method according to any one of the preceding claims.

26. A customer terminal for use in a communications network, the customer terminal including;

a network interface which in use receives tariff information via a communications network;

a store programmed with tariff information received at the said interface;

a meter for measuring use by the customer terminal of the network to which the tariff applies; and

a processor connected to the said meter and to the store and arranged to calculate using the said tariff information a network usage charge.

27. A method of operating a communications network substantially as described with respect to the accompanying drawings and in the accompanying paper.

28. A communications network substantially as described with respect to the accompanying drawings and in the accompanying paper.

29.A method of operating a communications network comprising

a) at a customer terminal measuring network usage;

b) communicating network usage data from the customer terminal to the network operator; and

c) the network operator sampling part only of the traffic communicated between a customer terminal and the network and for the sampled traffic comparing the network usage with the network usage data from the customer terminal and thereby detecting any discrepancy.

30. A method according to any one of claims 1 to 10 including communicating encrypted tariff data to the customer terminal, and decrypting the said tariff data at the customer terminal.

31. A method of operating a communications network including;

distributing a tariff via the communications network to a multiplicity of customer terminals connected to the communications network,

measuring at a customer terminal use by the customer terminal of network resources; and

calculating, using the results of the said step of measuring together with the said tariff, a charge for use by the customer terminal of the network to which the tariff applies.

32. A method of operating a communications network, including automatically varying, depending on network loading as detected at a customer terminal, a tariff for network usage by a customer terminal.

33. A method according to any one of the preceding claims, including communicating different tariffs from a plurality of different service providers to a respective customer terminal, at the customer terminal selecting between the service providers, and receiving network services via the selected service provider.

34. A method according to any one of claims 19 to 20, in which the step of establishing contracts includes associating a traffic conditioning agreement (TCA) with a respective customer.

35. A network arranged to operate by a method according to any one the claims 29 to 34.

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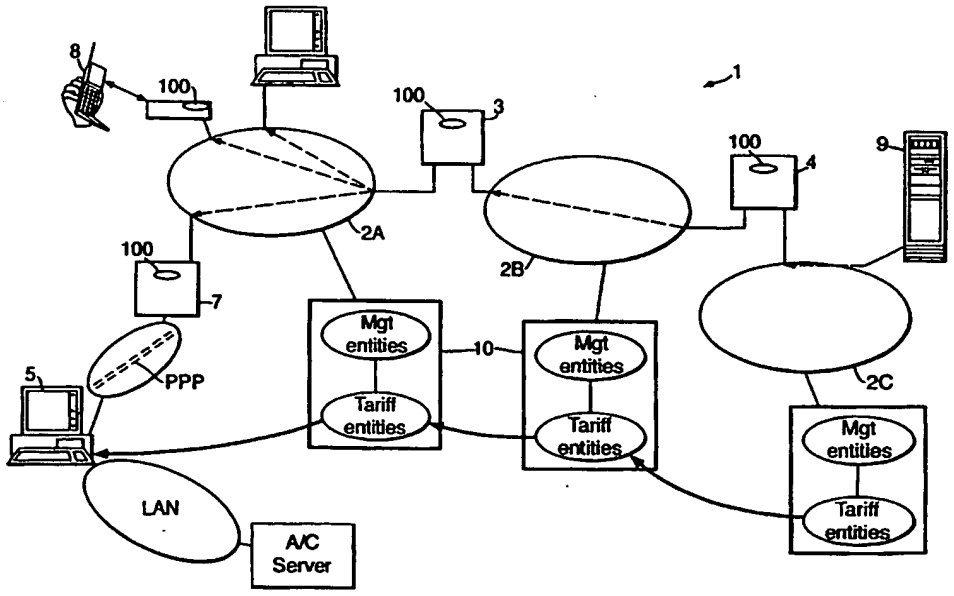
[Continued on next page]

(54) Title: ACCOUNTING IN A COMMUNICATIONS NETWORK



(57) Abstract: In a communications network, which may be a federated network such as the Internet, a tariff is distributed via the network to customer terminals. At each terminal a charge for use of the network is calculated by using the tariff. Different tariffs may be communicated for different services and a respective tariff may be varied depending upon the operational condition of the service. Different tariffs may be calculated for different customers and the tariffs may be varied in dependence upon the loading of network resources and different tariffs may have different volatilities. Part of the traffic from a user to the network may be sampled and the status of the user may be amended when a discrepancy is detected between the sampled parameters and the contracted parameters in the user's contract.

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L12/14 H04L12/56 H04Q3/00 H04L12/24 H04M15/28

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Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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[X] Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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(54) Title: COMMUNICATIONS NETWORK

(57) Abstract

In a communications network, which may be a federated network such as the Internet, a tariff is distributed via the network to customer terminals. At each terminal a charge for use of the network is calculated by using the tariff. Different tariffs may be communicated for different services and a respective tariff may be varied depending upon the operational condition of the service. Different tariffs may be calculated for different customers and the tariffs may be varied in dependence upon the loading of network resources and different tariffs may have different volatilities. Part of the traffic from a user to the network may be sampled and the status of the user may be amended when a discrepancy is detected between the sampled parameters and the contracted parameters in the user's contract.

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Communications Network

The present invention relates to a communications network, and in particular to charging mechanisms in such a network.

In conventional communications networks, such as national PSTNs (public switched telephone networks), a significant proportion of the network resources are devoted to metering and billing network usage. Studies have estimated these resources as consuming as much as 6% of the operational costs of a telecommunications company. The Internet, by contrast, does not in general incorporate metering and billing mechanisms for individual customers. The absence of the network infrastructure required to support metering and billing reduces the operational costs of the Internet compared to conventional telephony networks, and has facilitated the rapid expansion of the Internet . However the absence of appropriate billing mechanisms has significant disadvantages in terms of the characteristics of the traffic carried by the internet: it encourages profligate use of network resources, and diminishes the incentive for investment in network infrastructure to support new applications requiring, e.g., guaranteed quality of service (QoS).

According to a first aspect of the present invention, there is provided a method of operating a communications network including

distributing a tariff via a communications network to a multiplicity of customer terminals connected to the communications network, and

calculating, using the said tariff, a charge for use by the customer terminal of the network to which the tariff applies.

Reference to a terminal "connected to the network" is used here in the description and the claims to encompasses terminals, such as mobile wireless data terminals, which log on to a network temporarily, and other terminals which have a wireless connection to the network, as well as terminals which are permanently connected to a network by a fixed line. For example, a mobile terminal may log on to a network to receive the tariff and subsequently calculate the charge while off-line, and such an arrangement falls within the scope of this aspect of the invention.

According to a further aspect of the present invention, there is provided a method of operating a communications network including;

distributing a tariff via the communications network to a multiplicity of customer terminals connected to the communications network,

at a customer terminal measuring use by the customer terminal of network resources; and

calculating, using the results of the said step of measuring together with the said tariff, a charge for use by the customer terminal of the network to which the tariff applies.

These aspects of the invention provide a lightweight charging mechanism suitable for use, for example, in the Internet, or as an alternative to conventional billing mechanisms in other networks where the terminals have some data processing capabilitites. It removes the burden of metering and billing from the network infrastructure and instead distributes the tariff to the customer terminals, allowing charges to be calculated at the edge of the network. This approach offers far superior scalability by comparison with conventional approaches, and is therefore particularly suitable for use in a rapidly growing network such as the Internet.

Preferably the tariff algorithm is distributed to the multiplicity of customer terminals via the communications network to which the said tariff applies. In preferred implementations, the charging mechanism is designed to function even if some tariff messages distributed via the network are delayed or lost. Preferably the step of distributing the tariff includes steps of communicating separately a formula for calculation of network usage charges , and coefficients for use in the said formula.

The network overhead for charging is further reduced by providing users with the tariff algorithm and then updating only the relevant coefficients when the tariff changes.

Preferably the method includes measuring loading of network resources and determining a revised tariff in dependence upon the results of the said step of measuring loading.

A further significant advantage of the present invention is that it facilitates control of the use of network resources by amending the tariff to reflect the scarcity of a particular resource.

The steps of measuring loading and determining a revised tariff may be carried out automatically by a network management platform. Alternatively and

preferably, an algorithm for mapping congestion to price rises is distributed in the network, and preferably is located at customer terminals. Preferably the method includes operating a plurality of different services on the communications network, communicating different tariffs for different respective services to the multiplicity of customer terminals, and selectively varying a respective tariff depending on an operational condition of the respective service.

The different services may be distinguished only by different levels of QoS, or may be different in kind. This aspect of the invention may also be used in otherwise conventional networks, for example where billing is carried out centrally and tariffs are communicated to the end user only for information.

According to a further aspect of the present invention, there is provided a method of operating a communications network comprising:

operating a plurality of different services on the network;

communicating tariffs for the different services to a multiplicity of customer terminals via a common tariff distribution mechanism;

and selectively varying a respective tariff depending on an operational condition of a respective service.

According to a further aspect of the present invention, there is provided a method of operating a communications network, including

calculating for each of a multiplicity of customers, using a selected one of a plurality of different tariffs, charges for the use of network resources by a respective customer terminal attached to the network,

measuring the loading of network resources, and

varying one or more of the plurality of different tariffs in dependence upon the loading of the network resources, and in which different ones of the plurality of different tariffs have different respective volatilities.

This aspect provides customers with varying tariffs with different degrees of volatility. Then a customer needing greater stability can pay a premium to achieve that stability, while there still remains a band of higher volatility enabling the network operator to manage short term fluctuations in demand until longer term changes in tariff can be made.

According to a further aspect of the present invention, there is provided a method of operating a communications network in which at a point of access to the network a single blocking test only is applied to traffic entering the network .

Hitherto, a network such as the Internet has operated as a single service network. However it is now proposed that the Internet should become a multi-service network. For example, it may support multiple QoS levels for different applications, or might provide both multicast and unicast services to some but not all customers. The present inventors have recognised that, using conventional access control methods, this leads to a build up of multiple tests on access to the multi-service network to determine which service is being requested in each packet and then to check if it is a service which has been paid for by the relevant customer. This aspect of the invention overcomes this disadvantages by making a single blocking test that checks whether the customer is in a position to be punished for misuse of the network. Provided that this is the case, then the relevant packet is passed onto the network and all other appropriate checks are done in parallel, rather than blocking the packet while waiting for all the tests to be passed. If any subsequent tests are failed, for example if the packet has used a QoS level not paid for by the customer, then an appropriate punishment is imposed, for example by debiting a fine from a deposit lodged by the customer.

According to a further aspect of the present invention, there is provided a method of operating a communications network comprising:

a) communicating tariff data to a user terminal connected to the network;

b) calculating at the user terminal using the tariff data a charge for traffic communicated between the network and the terminal and making a payment;

c) sampling part only of the traffic communicated between users and the network and for the sampled traffic comparing any payments made by users and the payment due according to the tariff .

According to a further aspect of the present invention, there is provided a method of operating a communications network comprising

a) at a customer terminal measuring network usage;

b) communicating network usage data from the customer terminal to the network operator; and

c) the network operator sampling part only of the traffic communicated between a customer terminal and the network and for the sampled traffic comparing the network usage with the network usage data from the customer terminal and thereby detecting any discrepancy.

This aspect of the invention may advantageously be used in conjunction with one or more of the preceding aspects, but may also be used independently of them. For example, the customer terminal may measure usage data, and may send this data to the network operator, without having access to the current tariff. The network operator might then apply the relevant tariff and bill the user based on the user's own data. In order to be assured that the network usage data is trustworthy, the data can be compared with the expected usage data based on the network operator's own measurements in a sampled period. If the data are identical, then the data for other periods is assumed to be trustworthy. Alternatively, the tariff may be provided to the customer terminals and then, rather than the usage data being communciated explicitly, the customer calculates the usage charge. The payment of the usage charge, or equivalent accounting information is then communicated to the network operator, and the measured usage data is implicitly present in this communication.

According to another aspect of the invention, there is provided a method of operating a communications network, including automatically varying, depending on network loading as detected at a customer terminal, a tariff for network usage by a customer terminal. This aspect may be used in conjunction with, or independently of the other aspects of the invention.

Other aspects of the invention are as described and claimed below. The invention also encompasses communication networks, management platforms, routers and customer terminals adapted to operate in accordance with the methods of the invention, and computer-readable storage media bearing programs for implementing the invention in one or more of its different aspects.

DESCRIPTION OF DRAWINGS

Systems embodying the present invention will now be described in further detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic showing a network embodying the invention;

Figures 2a and 2b are graphs showing tariff functions;

Figure 3 shows the format of a differential service byte;

Figures 4a and 4b are schematics showing the component objects of a charging architecture for use with the network of Figure 1;

Figures 5a and 5b shows data passed between the accounting objects of Figure 4;

Figure 6 is a schematic showing protocol stacks on a customer terminal and in the network domain;

Figure 7 is a graph showing the variation of tariff with time;

Figures 8a to 8e are class diagrams for software implementing accounting and measurement objects;

Figure 9 is a diagram showing a graphic user interface (GUI) for use with the objects of figures 8a to 8e;

Figure 10 is a class diagram for software implementing tariff objects;

Figure 11 is a diagram showing an alternative embodiment; and

Figure 12 shows a user interface supporting a market in tariffs.

DESCRIPTION OF EXAMPLES

Systems embodying the present invention will now be described in further detail, by way of example only, with reference to the accompanying drawings, in which:

As shown in Figure 1, a communications network 1 includes a number of network sub-domains 2A-C. The network sub-domains may be under the control of different operators who may not trust each other. The network subdomains are interconnected by gateway routers 3, 4. In the present example the communications network is the Internet and supports both unicast and multicast Internet Protocol (IP) and associated protocols. A customer terminal 5 is connected via a public switched telephony network (PSTN) 6 and an access router 7 to a subdomain 2A. A single blocking test is applied to traffic at this point of access. The gateway routers 3,4, and access router 7 may be commercially available devices such as CISCO series 7500 routers and CISCO series AS5800 universal access server respectively. Other customer terminals are connected to the network, including a Java-enabled mobile terminal 8 and a data server 9. The customer terminal 5 may be connected via a LAN to an accounting server. The accounting server may include an accounting object as described below that receives measurement data from the customer terminal.

In addition to the local tariff variation mechanism that is described below, the network also uses network-based control of a number of tariff bands. A

network management platform 10 is connected to each subdomain. Each network management platform may comprise, for example, a computing system comprising a SPARC workstation running UNIX (Solaris) together with network management applications. The network management platform 10 hosts management entities and tariff entities. The network management platform communicates with agents 100 in managed devices connected to the respective subdomain, for example using SNMP (simple network management protocol). The management platforms monitors the overall loading of network resources in the respective subdomains, and, as will be further described below, adjust the tariffs for network use accordingly. The Net management platform (NMP) instructs the agent to monitor the device and report aggregated results at regular intervals back to the NMP, so the NMP can monitor the combination of all reports.

Tariff data is communicated to peer tariff entities in other subdomains and also to the customer terminals. The tariff data is multicast using, for example Distance Vector Multicast Routing Protocol (DVMRP) or Protocol Independent Multicast (PIM) dense mode. The tariff data channels are announced and monitored using protocols based on SDP (Session Description Protocol), SAP (Session Announcement Protocol) Charging is carried out on a "pay and display" model. Each customer terminal monitors its own network usage, for example by counting the number of packets it sends or receives across the network interface and the quantity of data (in bytes) in those packets. It calculates, using a tariff received via the network, the payment due to the network operator, and makes a corresponding payment into an account at the network operator. The network operator polices the use made by customers of the terminal by intermittently sampling traffic to or from a particular customer and comparing the use made and the use paid for.

The tariffs supplied to the customer terminals are divided into bands of different volatilities. The tariffs are varied under the control of the network operators to reflect the overall loading of the network. That is to say, if network loading becomes high, then the tariffs may be increased to reflect the scarcity of network resources.

A service provider may offer different products defined by different service level agreements, and/or by different price volatilities. For example product A might offer best-effort service at a fixed price while another product B might offer

best-effort service at a variable price. A service provider may adjust product prices on the basis of the following parameters: the price the service provider pays to its wholesale provider: competitors' prices; current resource utilisation; relevant demand for different products. In response to changes in these parameters, tariff adjustments may be effected in one of three ways. Firstly, a tariff may adjust prices on the basis of local observations of network loading, without necessitating explicit communication from the provider. This approach, which is described in further detail below, needs to be built into the tariff at the outset, and is limited to those price variations which are dependent exclusively on local observations. Secondly, the provider may tune a tariff by adjusting some of its parameters. This kind of adjustment is required when the decision is dependent on parameters which cannot be observed directly by the customer, e.g., variation in the wholesale price of network resources. Thirdly, the provider may completely replace a tariff. This is required when the existing tariff cannot accommodate the changes that are required.

The first of the tariff changes described above is necessarily carried out automatically. The second type of change may be performed manually, or by an agent that issues adjustments automatically in response to observations made by the service provider system. The third type of change is likely to be performed manually, as replacement of a new tariff will in general require an element of design requiring human input. However, it is possible that an agent might be employed to automatically switch tariffs for a product on the basis of a set of specified rules.

This section described a prototype that we implemented to demonstrate the tariff subsystem outlined above. Features of the design include:

- using mobile code to represent tariffs and associated user interface components;
- use of a repeated multicast announcement protocol to communicate tariffs and tariff adjustments efficiently;
- using dynamic class loading and reflection in order to receive and tune tariffs.

The prototype consists of a library of general-purpose Java classes and two specific applications, namely:

- a provider system which allows the provider to introduce, replace, and tune tariffs for a number of products;

- a customer system that enables customer to keep track of the charges being applied for the products they are using.

The provider system services multiple instances of the customer system running on different hosts in a multicast-enabled network. A multicast announcement protocol is used to communicate tariff changes from the provider system to customer systems.

In order to maximise flexibility with respect to the definition of tariffs, we chose to represent tariffs using Java classes. This technique is also used to supply user interface components to customers to support visualisation of the behaviour of a tariff.

The `Tariff` interface acts as the base class for all tariffs. This defines a single operation get `GUI()` which returns as a Java SWING component that can be incorporated into the customer's GUI (graphical user interface). This GUI component enables the customer to visualise the behaviour of the tariff using techniques appropriate to the tariff.

Subclasses of the `Tarrif` interface establish a set of tariff types, each of which is associated with a different set of measurement and input parameters. These parameters are identified by listing them in the signature of the `getCharge()` method. For example, the interface `RSVPTariff` defines `getCharge()` as receiving n RSVP `TSPEC`, allowing for the definition of tariffs that compute price on the basis of the characteristics of an RSVP reservation BLB98. On the other hand, the interface `PacketCountTariff` defines `getCharge()` as receiving measurements of packets in, packets out, and current congestion (typically measured as a function of packet drop), allowing for the definition of tariffs that are dependent on packet counts and sensitive to congestion. Other tariffs may be added as new forms of usage-measurement emerge.

Tariffs are defined by providing implementations of the various tariff interfaces described above. For example, the tariff `PacketCountLinear` implements `PacketCountTariff` to compute charges in proportion to packet counts. Another tariff `CongestionSensitiveLinear` works on a similar basis, but adds a penalty charge if the customer does not stay within a specified traffic limit in the presence of congestion.

In addition to the tariff interface implementation, a tariff may make use of other 'helper' classes to assist in its operation, as well as one or more user interface component classes for customer visualisation purposes. A provider-side user interface may also be required in order to enable the provider to make tariff adjustments.

A complete tariff description consists of a set of Java classes, some of which are destined for the customer system and others which are intended for use by the provider system [3]. The customer-side classes are bundled into a Java archive (JAR) file to facilitate processing by the provider system.

In order to deploy a new tariff, the provider system first loads the tariff classes which it requires into its execution environment. It then loads the customer-side bundle, serialises it, signs it with a private key, and uses an announcement protocol to distribute it to customer systems. The use of a signature makes it possible for customers to verify that received tariffs are authentic.

Upon receiving the bundle, each customer system verifies the signature (using the public key matching the provider's private key), and at the activation time specified in the announcement protocol header which may be significantly later, e.g. hours or days, unpacks the bundle, and loads the classes into its execution environment using a purpose-built dynamic class loader. An instance of the received tariff class is created and installed in place of the previous tariff. If the tariff has a user interface component (obtained by calling the tariff object's `getGUI ()` method), then it replaces the user interface of the previous tariff. The change in user interface services to notify the user that the tariff has changed.

Tariff adjustment involves the remote invocation of an operation which is specific to the tariff currently in force. This means that a customer system cannot know the signature of this operation in advance of receiving the tariff i.e. the operation will not be listed in any of the tariff interfaces known to the customer system.

In order to get around this problem, use is made of the "reflection" feature supported by Java. In order to disseminate a tariff adjustment, the provider creates an instance of an `Invocation` object, which stores the name of the operation to be called, together with the parameters that are to be supplied to it. This object is then serialised, signed, and announced using the announcement

protocol. When an adjustment is receive and verified by a customer system, the `Invocation` object is de-serialised and applied to the current tariff by using reflection to invoke the described operation.

In order to simplify the announcement protocol, adjustments are required to be idempotent and complete. Idempotency guarantees that a tariff will not be adversely affected if an adjustment is applied more than once. Completeness implies that an adjustment determines the entire parameter set of a tariff object, so that an adjustment completely removed the effects of any previously applied adjustments.

The customer system may apply a tariff by repeatedly invoking the `getCharge()` operation supported by that tariff every second, and adding the returned value to the cumulative charge. The parameters supplied to `getCharge()` depend on the kind of tariff currently in force. For example, if the tariff is an implementation of `PacketCountTariff`, then measurements of inbound packets, outbound packets and congestion over the past second are required. However, if the tariff is an implementation of `RsvpTariff`, then only a `TSPEC` describing the current reservation is required[4]. This implies that a customer system can only subscribe to a product if it can supply the parameters require by the tariff associated with hat product.

Each invocation of the `getCharge()` method also results in an update to the tariff-specific user interface. For example, in the `CongestionSensitiveLinear` tariff, the usage parameters supplied to `getCharge()` are used to update the graphical displays of traffic and congestion.

The announcement protocol is used to communicate serialised tariffs and adjustments from a provider system to multiple customer systems. The number of customer systems is assumed to be large, and a repeated multicast solution is adopted.

Each product supported by a provider is assigned a multicast channel for announcement purposes. Customer systems listen to the channels corresponding to the products that they are using. In the current implementation, it is assumed that each customer system has knowledge of well-known multicast addresses for the products it is interested in.

For each product channel, the provider repeatedly announces the current tariff and the most recent adjustment made to it (if any). Each announcement carries a version number, which is incremented each time the announcement is changed. Customer systems only process announcements when a version number change is detected. If a new customer joins a channel, it waits until it receives a tariff before processing any adjustment announcements. Furthermore, an adjustment is only applied if its announcement version is greater than that of the current tariff, thereby ensuring that a missed tariff announcement does not result in the application of a subsequent adjustment to an old tariff.

While centralised monitoring and control of tariffs by the network management platform is effective to respond to global changes in the loading of the network, it is difficult to handle localised congestion in this way. It is difficult to cause a price rise signal to be multicast in such a way that the signal is only received by those attempting to communicate packets through the point of congestion. This would require a separate multicast transmission for each element in the Internet , e.g. a multicast for every different queue on every interface of every router. Alternatively some aggregation of price rises triggered by local resource loading might be used. This however would mean that price rise signals were sent to users who were not making use of the congested resource. This in turn would make it necessary for the price rise signal to be damped, reducing the ability of the price rise to reduce the demand on the congested resource.

To overcome these difficulties, the tariff algorithms installed on the customer terminals are arranged to respond automatically to congestion in a network resource being used by the terminal. Each algorithm includes a function which varies the price for network usage in dependence upon the detected congestion level. This function may be integrated in the main tariff algorithm, or, as in the example described here may be a separate algorithm used to calculate a premium to be added to a price calculated in accordance with the main tariff algorithm.

The main tariff algorithm calculates a price P as a function of a number of quality parameters, Q_1, Q_2, Q_3 where, for example, Q_1 is a specified latency for packets communicated across the interface between the customer terminal and the network, Q_2 is the reserved bandwidth for the transmission, Q_3 is a specified level of reliability corresponding to a maximum permissible level of packet loss.

The price P is then given by:

$$P = f(Q_1, Q_2, Q_3.....)$$

An example of the pricing function in terms of one of the quality parameters Q is shown schematically in Figure 2a.

The congestion tariff algorithm calculates a premium ΔP which is a function of one or more congestion parameters C:

$$\Delta P = f(C_1, C_2 ...)$$

The congestion parameters provide a measure of the loading of the resources which a customer terminal is making use of at any given time. In the present example the ratio of packets lost to packets received is used as the congestion parameter. This parameter is readily calculated, for example in the case of packets using TCP (transport control protocol), or RTP (real time protocol) over UDP (user datagram protocol), since such packets include a sequence number. Figure 2b shows one example of the function for generating the premium. In this case, the premium increases as an approximately exponential function of the congestion, so that at low congestion levels a small premium is charged, while if congestion increases still further, then at higher levels of congestion the premium increases sharply.

In an alternative implementation, an explicit congestion signal is added by any congested router within the network to packets transmitted to the customer terminal.

Although only a single main tariff and premium are described here, in practice different subdomains, and different service providers associated with each subdomain, may each have a different pricing structure, with different main and premium tariffs. However, there is across all the subdomains a common relationship between network loading levels and congestion signalling.

The operation of this second implementation will now be described in the context of a network operating using a differentiated service as described in the Internet Engineering Task Force draft "Differentiated Services Operational Model and Definitions" and in the paper by David D Clark (MIT), "A Model for Cost Allocation and Pricing in the Internet", presented at MIT Workshop on Internet Economics, Mar 1995, URL:http://www.press.umich.edu/jep/works/ClarkModel.html. In a network implementing differentiated services, nodes are arranged to discriminate between

packets to provide different levels of service. This capability might be used, for example, to accord delay-sensitive data, such as data generated by an IP telephony client, a higher priority compared to other data, such as email data. At the network edge, for example at a client terminal running the IP telephony client, bits in a TOS (type of service) octet contained within each packet header are set to indicate the appropriate service level. Those bits are used by routers within the network to determine how the relevant packets should be handled.

The TOS octet when used in this way is termed the DS (differential service) byte. The format of the differential service byte is shown in Figure 3. Bit zero, labelled "IN" indicates whether the packet is inside or outside a defined profile. Bits 1 to 5 labelled "PHB" define a "per-hop-behaviour" that is they indicate how, for example, a router should handle the packet, e.g. by according it lower or higher priority. Bits 6 to 7, in this particular form of the DS byte, are used for explicit congestion notification (ECN). One of these bits is set to indicate whether the routers in the path of the packet are capable of setting the ECN field, and the other bit is used as a flag which is set (by ECN capable routers) when congestion, or loading which would potentially lead to congestion, occurs. Random Early Detection (RED) algorithms are currently implemented in routers. These algorithms measure average queue length within the packet buffers of a router. An exponential moving average is calculated. When that average queue length exceeds a predetermined threshold, then the router signals that congestion is occurring. Conventionally this signalling has been done simply by dropping a packet. However, in the context of an ECN scheme, the router, instead of dropping a packet, sets an ECN bit in a packet header to indicate that congestion is occurring. This is done probabilistically: that is, some only of the packets passing through the router are marked. The probability of a packet being marked increases with the average queue size. In the rare case that the queue increases to a length where the router buffers are full, then packets are dropped, rather than an ECN bit being set. In this case ECN bits are set for all the remaining packets.

In operation, if the client terminal 5 is accessing a data source on the server 9, congestion may occur, for example, at router 4 which links network sub-domains 2B and 2C. RED-like algorithms in the router 4 detect that the queue lengths in the router buffers, as calculated using the exponential moving average, exceed a predetermined threshold. Accordingly some of the packets from the

server 9 en route to the client terminal have the ECN bit of the DS byte set by the router 9 to mark the fact that congestion is occurring. At the client terminal, the DS byte in the headers of incoming packets is read. A moving average of the number of packets containing an ECN bit which is marked is calculated. This average then provides the congestion parameter C_1 which is used to calculate the premium:

$$\Delta P = f(C_1).$$

The total price to the user P_{TOT} is then calculated by adding together the prices determined by main tariff algorithm and by the premium algorithm:

$$P_{TOT} = P + \Delta P.$$

This total price is passed to a cost decision agent running on the client terminal. This cost decision agent is programmed with user defined rules. These might state, for example, that the cost decision agent should authorise the system to proceed with a connection as long as the total cost averaged over a certain time period falls below a predetermined threshold, e.g. of £0.01 per minute, and that the cost decision agent should suspend a connection and alert the user if the cost rises above that threshold. Alternatively, as previously noted, the cost decision agent may handle several applications simultaneously, and may be programmed to slow down one of the applications as the premium for using a data source accessed by that application increases.

For ease of description, the preceding sections have treated in isolation the local variations in tariff in response to congestion. In practice, this mechanism will in general be combined with other responses to congestion, and with other sources of variation in the tariff. Also, a decision to proceed with a transmission despite congestion will in general require the consent of parties at both ends of the transmission. Considering the entire system of the data source, network and routers and the data receiver, the implementation of an increase in tariff (also termed here a "fine") in response to locally detected congestion occurs as a last resort. Other responses are implemented first, in the following numerical order:

1.the network re-routes around congestion

2.the network borrows capacity from lower levels of service (lower in the context of

the relevant dimension(s) of QoS) including the best effort service

3.the network introduces extra capacity (possibly automatically)

4.the end-system establishes that the congestion is on the shared network and not just on the access links or end systems

5.the end-system sets QoS requirements to a "higher" level (if cheaper than the fine for ignoring congestion at the current level)

6.the end-system decides it is essential to ignore the congestion, given the fine for doing

so might be quite high

7.both (all) end-systems agree to ignore the congestion.

Typically, it is at step 4 that an ECN signal is generated. Steps 1 to 3 precede the generation of this signal and steps 5 to 7 follow the generation of the ECN signal.

The last step prior to proceeding with a connection and paying the premium for doing so is establishing agreement by both parties. Accordingly, when the customer terminal detects congestion, either through receiving explicit congestion notification, or through detection of a relevant parameter such as packet loss, the customer terminal signals this fact back to the or each other end system. In the present example therefore, the client terminal 5 signals to the data server 9 that congestion is occurring. The data server is programmed with rules, which as at the customer may be implemented as an agent, which determine the response to such a signal. For example, the server may refuse service in these conditions. As described previously with respect to Figure 1, in the present example tariffs are multicast through the network from network operators to the customer terminals, and charging is carried out using a "pay and display" process. Figures 4a and 4b shows the objects used to implement the charging architecture in this case. Figure 4a shows the higher level objects and 4b shows the component objects used in a software implementation of the architecture of Figure 4b. In Figure 4a, objects on the client terminal are shown in the half of the Figure labelled "customer" and objects on the access router 7 and the corresponding network sub-domain are shown in the half of the Figure labelled "edge network". The objects on the customer terminal include a session control object S, a customer business rules object B_c , a customer pricing object Pr_c, a QoS manager Q, a customer accounting object Act_c and a customer measurement object M_c. The business rules object B_c receives information on those aspects of the session which involve liability for payment and receives current pricing data from the

pricing object Pr_c. The customer business object makes decisions, under the customer's policy control on which chargeable services are utilised, and how much of the chargeable services are utilised. These decisions are fed to the QoS manager Q, which decides which mechanisms are used to achieve the requirements. The QoS manager then controls the customer measurement object M_c to determine which aspects of traffic and service to measure and which aspects to ignore. The measurement object then records the selected aspects of the traffic, for example counting the number of packets received by the customer terminal and the QoS levels for those packets. These data together with the current tariffs, including any premium for congestion, are then used by the customer terminal to determine the charge payable to the network operator. The measurement object M_c is also programmed with instructions which determine the frequency with which it passes data to the customer accounting object Act_c . The customer accounting object Act_c passes payments to an accounting object Act_p in the network provider's domain.

The accounting objects on the customer terminal may be implemented using a small encrypted flat-file database. On the network provider's side, the equivalent objects may be implemented using a larger database that is scaleable to handle e.g., tens of thousands of customer accounts. An object request broker (ORB) is used for communication between the customer-side objects and the network-side objects, implemented using commercially available tools such as ORBIX (TradeMark) from Iona Technologies plc.

On the network provider's side, that is to say within the subdomain to which the customer terminal is connected, the customer's traffic is measured by a version of M, denoted M_p, but only on a sampling basis determined by the policing function, Po. That is to say, the network operator samples the customer's traffic only intermittently. Po controls where in the network measurements are made in order to capture all of any particular customer's traffic. A bulk measurement function, M_b, is responsible for reporting aggregate traffic levels, as reflected in the moving average of the router queue lengths, to the pricing object, Pr_p. Bulk measurements would typically be collected from across the provider's domain to a centralised pricing function (which would be replicated for reliability). Pr_p sets prices taking into account the business rules from the network provider's business object, B_p, as well as the current traffic levels reported by Mb and pricing from

neighbouring providers (see below). The policing function, Po, compares sample measurements from M_p with accounting messages received at Act_p as a result of the customers own measurements . If it establishes that the accounts are insufficient it might restrict service at the access control gateway, Acs, or initiate some other punishment. Encapsulated within the accounting object another policing object checks the accounts match the payments within the contracted time for payment. Finally, the identity mapping function, I, provides a mapping between a customer's identity (account, digital signature, etc.) and their current network address (typically allocated by the ISP, whether unicast or multicast).

Figure 5 shows the data which are passed between the accounting objects. In this example the account data comprises: account identity; bill record identity; service type identifier; source address; destination address; tariff identity; time; period (i.e. the period covered by the bill record); units; cost; and currency. In addition, the payment data comprises the amount of money and the currency of payment.

Figure 6 shows the measurement region within protocol stacks on the customer terminal and in the network domain. Ideally there would be two measurement points within this region, one trusted by the customer and one trusted by the network, for example at the two points referenced (a) in the Figure. For ease of implementation, a single measurement point (b) trusted by both parties may be used. This might be implemented, for example within a secure module such as a cryptographic card on the client terminal. As an alternative, measurements may be made at different points with some possibility of discrepancies between measurements. On the network the practical measurement point is at the first access device(s) that, for each customer, inspects network layer headers (c)(IP in this case). ISPs should not measure any deeper into their network (d) because their access network and systems will introduce delays and losses.

For an individual customer (e.g. on dial-up access), a practical point at which to measure would also be alongside the network layer but in their end-system's stack (e). Ideally these measurement points would be lower in each stack to be closer to the interface between the two parties and less likely to be affected by contention in the stack. However, measuring at the link layer (f-f) would be inappropriate because only some chargeable parameters set at the

network layer will ever be reflected in link layer frames; network level multicast, end-end latency requirements etc. may never be visible at the link layer. Also, link layer headers would need to be ignored when measuring packet sizes for bandwidth calculations to avoid apparent discrepancies where different link technologies are chained together.

In the reception direction (up the stack) this choice of measurement points implies that the lower layers must be dimensioned (buffer sizes, interrupt and thread scheduling priorities) to cope with the most stringent QoS requirements of higher layers. As frames are taken off the physical media, the machine must be able to pass data up the stack without any chance that usage-charged data gets discarded (e.g. due to buffer overflow caused by interrupt contention) before it gets to the network layer. It is at the network layer where the ISP's service is to be measured and where it is most convenient for QoS requirements to control correct differential treatment of the various flows as they are passed further up the stack (on end-systems) or forwarded (on routers).

The measurement objects described above may be implemented using, with appropriate modifications, publicly available network metering software such as Nevil Brownlee's NeTraMet system. This is a software meter which conforms to the IETF internet accounting architecture described in RFC 2063 and RFC 2064. The meter builds up, using "packet sniffing", packet and byte counts for traffic flows, which are defined by their end-point addresses. Although generally, Addresses can be ethernet addresses, protocol addresses (IP, DECnet, EtherTalk, IPX or CLNS) or 'transport' addresses (IP port numbers, etc), or any combination of these, in the present implementation IP addresses only are used. The traffic flows to be observed are specified by a set of rules, which are downloaded to NeTraMet by a 'manager' program. Traffic flow data is collected via SNMP (Simple Network Management Protocol) from a 'collector' program.

Figure 7 shows how the main tariff determined by the network operator varies in time. In the Figure, curve A is the spot price calculated to reflect the loading of the network at any instant. Curve B is one of a number of different tariff bands. Different tariff bands have different volatilities, and the customer pays a premium for bands offering greater stability. Tariffs are communicated to the customer terminals using a hierarchy of channels carried by the network. An initial contract between a customer and a service provider a single channel address

that might typically hold new announcements distributed some months apart (e.g. for contract variations or for new services specifying which second level channel to listen to for tariffs or for downloading new code to handle new tariff structures). The second level channels might deliver updates hours apart which simply announce the addresses of third level channels for the most volatile information. These third level channels may carry updates at intervals of less than a second. Prices for many services may be carried on one channel. For greatest efficiency, this one channel may be split into several channels at times of highest volatility, and re-aggregated into a single channel in more stable periods.

Instead of Charging a standard tariff for each customer based on their usage, the provider might wish to sell an individual service level agreement (SLA) to each customer. Alternatively, customers might be able to choose to accept service under one of a (possibly large) range of SLAs. Such an SLA might include obligations on the provider to provide a certain percentage service availability and other aspects of quality not directly to do with communications traffic. However, the SLA might also include a traffic conditioning agreement (TCA), such as is envisaged between providers and between providers and major customers in the proposed IETF differentiated services architecture. A TCA contains obligations on the provider's quality of service on condition that the customer's traffic is within a certain profile.. Often, if traffic is outside the profile, the TCA still applies to the balance of traffic within profile. A profile might stiplate the maximum size and duration of bursts the customer should generate, or the peak rate, or the moving average rate under specified parameters. Theoretically, TCAs can also be applied to received traffic on the assumption the customer can control the rate of remote senders using rate control protocols. In the diffserv proposals, TCAs are policed by a traffic policer installed at the entrance to the provider's network. These might be specialist hardware or combined with the function of the router. Traffic policers either drop or mark any traffic outside the agreed profile which is configured into the policer. The choice of which packets to mark is random. In the diffserv proposals, the first 6 bits of the DS-byte are termed the code-point. If the last five bits of the code-point are within a certain range, the first bit of the DS byte can be used as a flag to indicate whether the packet is out of profile. Packets out of profile are still forwarded, but they take first precedence for dropping in any congested queue of any downstream router. The diffserv proposals also suggest that customers might also operate policers in series with the provider policer to mark

packets that are out of profile. If done under the control of the customer's application, this enables the customer to choose which packets are marked based on their importance to the application.

In our alternative approach, we avoid the need for the provider to operate traditional traffic policers. The customer still marks their packets as suggested by diffserv proposals. However, the provider merely meters the traffic on a sampled basis. The meter checks the traffic conforms to the TCA but it operates in parallel to the data flow which can be forwarded while metering proceeds on the memory copy of the packet header in the router. If traffic is out of profile, the customer is penalised. For instance, either she is cut off, or fined or her credit rating is reduced. This is in contrast to the traditional traffic policer which 'punishes' the packets that are out of profile by marking or dropping them. In this traditional approach, the packet cannot be forwarded until it has passed the police check. If it had been forwarded, it would not be able to be marked or dropped.

The advantage of this approach is that forwarding is typically much faster than policing. For instance, if all-optical technology is used for forwarding, it is much more complex to implement policing and will therefore be unlikely to be achieved in optics for some time. With the proposed approach, samples of traffic can be tapped off the optical flow to be policed in electronics out of band. The sampling rate can be chosen to allow the traffic to fill a buffer before being passed to the policer. Thus the policer can 'catch up' with the optics between samples by emptying the buffer. This is an application of Amdahl's law concerning the maximum performance gain from a parallel process being constrained by the critical (slowest) path.

Tables 1 to 7 below list Java source code used to implement two different tariffs. The code of table 1 establishes the operations used for communication between a customer system and a tariff algorithm downloaded by the customer system. Table 2 shows a linear tariff algorithm, in which the tariff depends on the total of the packets sent and packets received by the customer together with a congestion parameter. Table 3 shows the code for generating the customer display in this case. Table 4 shows the code used to display the tariff at the network operator's server. Table 5 shows an exponential tariff algorithm. Table 6 generates the customer display and Table 7 the operator display for the exponential tariff algorithm. By downloading Java code to generate the user

interface, that interface can be tailored to the requirements of the particular tariff, and can be adapted as the tariff changes.

The multicasting of tariffs may be used to support a market in network services from different service providers. Figure 12 shows a modified user interface adopted at the customer terminal in this case. This user interface might be adopted, for example, when the customer requires a multicast audio-video conference involving data, audio and video applications. A slider control interface is used to set the required quality Q level for each of the component data streams. The underlying application then translates the Q parameter into appropriate performance parameters such as required bandwidth, packet loss and latency. The customer terminal receives multicast tariffs from two different service providers or network operators, SP1 and SP2. The user interface, in addition to displaying the cost with the currently selected service provider, SP1, also displays the cost were the other service provider, SP2 to be selected. The user may opt to switch to the second service provider SP2 for one or all of the data streams. For example, the current costs of the video data stream in the example shown in the Figure is substantially reduced by switching to the second service provider. The decision to switch may be made manually by the user, or might be automated through a software agent running on the customer terminal. In the context of network such as that illustrated in Figure 1, the switch to a different provider may be made by dialling a different number using the customer terminal modem so that the PPP connection is made via a different access router, possibly on a different network domain. Such switching between service providers is facilitated when using a protocol such as Internet Protocol version 6 which, in a proposed implementation, offers both host and site addresses, where host addresses may remain stable even when a site IP address changes. In this case, the customer terminal would have both a host address and a site address and while the site address would change on switching service providers, the host IP address remains constant.

Although the examples so far described have been in the context of federated packet data networks, such as the Internet, many aspects of the invention can also be used with advantage in other types of network, such as in a circuit-switched PSTN (public switched telephony network). Figure 11 shows an example of the invention applied in this context. In this network, customer terminals 81, which are in this example so-called intelligent phones, that is

telephones incorporating a microprocessor and a data interface, are connected via local exchanges 82 and trunk exchanges 3 to the telephony networks. The trunk exchanges 83 are connected via a common channel SS7 (signalling system number 7) signalling network to a service control point 85 that is responsible for the execution of advanced call control functions. The service control point 85 is also connected to an operational support server 86 that is responsible for billing operations, and that, in this example, controls the setting of tariffs for the network. The OSS server and customer terminals include tariff entities (TE). The fixed PSTN network is also interconnected via a gateway 87 to a cellular GSM network 88. Base Stations BS in the cellular network communicate signals to intelligent mobile phones 89. In operation, network tariffs are distributed to customer terminals via the PSTN network and via the GSM network. Conveniently, the tariff may again take the form of Java functions which are executed on processors in the customer terminals. The Java functions may be streamed as Internet packets. In one implementation, these Internet packets may be distributed via the PSTN networks and GSM networks themselves. For example, the packets may be encapsulated and transported to the trunk exchanges using the MTP (message transport part) transport layer and may be communicated onwards to the customer terminals using out-of-band signalling. Alternatively, a separate data connection may be established between the OSS server and the customer terminals via the public internet. As in the examples above, the network operator monitors the loading of resources within the network and may transmit signals to the tariff entities in the customer terminals to change the tariff to reflect the scarceness or otherwise of relevant resources. Customer terminals may themselves monitor network loading and automatically generate variations in the tariffs. Usage of network resources may be measured locally by the customer terminals instead of conventional billing carried out within the network. The network operator may police the measurement of usage data by carrying out sampling, as described previously.

Table 1

```
// Generated by Together
package com.bt.jungle.lsma.charging.pricing;

import com.sun.java.swing,JComponent;

/**This establishes the operations used for
communication between the customer system
and the downloaded algorithm.
@author Mike Rizzo*/
public interface Tariff {
Jcomponenet getGUI( );
Float getPrice (int pkin, int pkout, int cng);
```

Table 2

```
package algorithms.linear;

import com.sun,java.swing.JComponent;
import com.sun.java.swing.JTextField;

import com.bt.jungle.lsma.charging.pricing,Tariff ;

public class LinearAlgorithm implements Tariff {
        private float rate;
        private LinearAlgorithnDisplay display;
        public LinearAlgorithm ( ) {
                display = new LinearAlgorithmDisplay ( );
                setRate (new Float(1));
        }
        public float getPrice (int pkin, int pkout, int cng) {
                return (pkin + pkout + cng) * rate;
        }
        public JComponent getGUI( ) { return display; }
        public void setRate (Float f) {
                rate = f.floatValue( ) ;
                display.setRate (rate) ;
        }
}
```

Table 3

```
// Generated by Together

package algorithms.linear;

import com.sun.java.swing.JPanel;
import com.sun.java.swing.JTextField;
import com.sun.java.swing.Box;
import com.sun.java.swing.JLabel;

public class LinearAlgorithmDisplay extends Jpanel {
        private JTextField tfRate = new JTextField (4);
        public LinearAlgorithmDisplay ( ) {

                Box vbox = Box.createVerticalBox ( ) ;

                Box hbox = Box.createHorizontalBox ( ) ;
                hbox.add (Box.createHorizontalGlue ( )) ;
                hbox.add (new Jlabel ("Rate:"));
                hbox.add (Box.createHorizontalGlue( ));
                hbox.add (tfRate);
                tfRate.setEditable (false);
                hbox.add (Box.createHorizontalGlue( ))
                vbox.add (hbox);

                add (vbox());
        }
        public void setRate (float f) {
                tfRate.setText (String.valueOf (f));
        }
        }
```

Table 4

```
// Generated by Together
package algorithms.linear;

import com.sun.java.swing.*;
import java.awt.event.*;

import com.bt.jungle.lsma.charging.pricing.provider.*;
import com.bt.jungle.util.*;

public class LinearAlgorithmGUI extends Jpanel {
        private JTextField tfRate - new JTextField ( );
        private TuningMessageListener tuningMessageListener;
        private final static String DEFAULT_RATE = "1.0";
        public LinearAlgorithmGUI (TuningMessageListener tml) {
                tuningMessageListener = tml;
                tfRate.setText (DEFAULT_RATE);

                Box vbox = Box.createVerticalBox( );

                Box hbox = Box.createHorizontalBox ( );
                hbox.add (new Jlabel ("Rate:"));
                hbox.add (Box.createHorizontalGlue( ));
                hbox.add (tfRate);
                hbox.add (Box.createHorizontalGlue( ));
                hbox.add (hbox);

                JButton bTransmit = new JButton ("Transmit");
                bTransmit.addActionListener (
                        new ActionListener ( ) {
                                public void actionPerformed (ActionEvent e) {
                                        transmit ( ) ;
                                }
                        }
                );
                hbox = Box.createHorizontalBox( );
                hbox.add. (Box.createHorizontalGlue( ));
                hbox.add (bTransmit);
                hbox.add (Box.createHorizontalGlue( ));
                vbox.add (hbox);

                add (vbox);
        }
        void transmit ( ) {
                try {
                        Float f = new Float (tfRate.getText( ));
                        Object  args [ ] = new Object [1];
                        Args [0] = f;
                        TuningMessageListener.notify(
```

```
                    new Invocation ("SetRate", args)
                );
            }
            catch (Exception e) {
                e.printStackTrace ( );
            }
        }
    }
```

Table 5

```
package algorithms.exp;

import com.sun.java.swing.JComponent;
import com.sun.java.swing.JTextField;

import com.sun.java.lsma.charging.pricing.Tariff;

public class ExpAlgorithm implements tariff {
        private float min;
        private float base;
        private float divisor;
        private ExpAlgorithmDisplay display( );
        public ExpAlgorithm( ) {
                display = new ExpAlgorithmDisplay ( );
                setMin (new Float (1));
                setBase (new Float (2));
                setDivisor (new Float (10));
        }
        public float getPrice (int pkin, int pkout, int cng) {
                return min + (float)math.pow
(base,(pkin + pkout + cng)/divisor);
        }
        public JComponent getGUI( ) {return display; }
        public void setMin (Float f) {
                min = f.floatValue( );
                display.setMin(min);
        }
        public void setBase (Float f) {
                base = f.floatValue( );
                display.setBase(base);
        }
        public void set Divisor (Float f) {
                base = f.floatValue( );
                display.setBase (divisor);
        }
}
```

Table 6

```
// Generated by Together

package algorithms.exp;

import java.awt.GridLayout;
import com.sun.java.swing JPanel;
import com.sun.java.swing.JTextField;
import com.sun.java.swing.Box;
import com.sun.java.swing.JLabel;

public class ExpAlgorithmDisplay extends Jpanel {
        private JLabel tfDisplay = new JLabel ( );
        private float min, base, div;

        public ExpAlgorithmDisplay ( ) {

                add (tfDisplay);
        //              tfDisplay.setEditable (false);
                updateDisplay ( );
        }
        private void updateDisplay ( ) {
                tfDisplay.setText ("price = " + min + " + " + base +
"^((pkin+pkout+cng)/" + div +")");
        }
        public void setMin (float f) {
                min = f;
                updateDisplay ( );
        }
        public void setBase (float f) {
                base = f;
                updateDisplay ( );

        public void setDivisor (float f) {
                div = f;
                updateDisplay ( );
        }
}
```

Table 7

```
// Generated by Together

package algorithms.exp;

import java.awt.GridLayout;
import com.sun.java.swing.*;
import java.awt.event.*;

import com.bt.jungle.lsma.charging.pricing.provider.*;
import com.bt.jungle.util.*;

public class ExpAlgorithmGUI extends Jpanel {
        private JTextField tfMin = new JTextField ( );
        private JTextField tfBase = new JtextFfield ( );
        private JTextField tfDivisor = new JTextField ( );

        private TuningMessageListener tuningMessageListener;
        private final static String DEFAULT_MIN = "1.0";
        private final static String DEFAULT_BASE = "2.0";
        private final static String DEFAULT_DIV = "10.0";

        public ExpAlgorithmGUI (TuningMessageListener tml) {
                tuningMessageListener = tml;
                tfMin.setText (DEFAULT_MIN);
                tfBase.setText (DEFAULT_BASE);
                tfDivisor.setText (DEFAULT_DIV);

                Box vbox = Box.createVerticalBox ( );

                vbox.add (new JLabel ("price = min + pow (base,
(pkin+pkout+cng)/divisor)"));

                vbox.add (Box.createVerticalGlue ( ));

                Jpanel panel = new JPanel (new GridLayout (3,2));
                panel.add (new JLabel ("Minimum"));
                panel.add (tfMin);
                tfMin.addActionListener (
                        new ActionListener ( ) {
                                public void actionPerformed (ActionEvent e) {
                                        transmit ("setMin", tfMin);
                                }
                        }
                );
                panel.add (new JLabel ("Base"));
                panel.add (tfBase)
                tfBase.addActionListener (
                        new ActionListener ( ) {
```

```
                        public void actionPerformed (ActionEvent e) {
                        transmit ("setBase", tfBase);
                    }
                }
            };
            panel.add (new JLabel ("Divisor"));
            panel.add (tfDivisor);
            tfDivisor.addActionListener (
                new ActionListner ( ) {
                    public void actionPerformed (ActionEvent e) {
                        transmit ("setDivisor", tfDivisor);
                    }
                }
            );
            vbox.add (panel);

            add (vbox)
        }
        void transmit (String m, JTextField tf) {
            try {
                Float f = new Float (tf.getText ( ));
                Object args [ ] = new Object [1];
                args [0] = f;
                tuningMessageListener.notify(
                    new Invocation (m, args)
                );
            }
            catch (Exception e) {
            e.printStackTrace ( );
            }
        }
    }
```

CLAIMS

1. A method of operating a communications network including

distributing a tariff via a communications network to a multiplicity of customer terminals connected to the communications network, and

calculating using the said tariff a charge for use by the customer terminal of the network to which the tariff applies.

2. A method according to claim 1, in which the tariff algorithm is distributed to the multiplicity of customer terminals via the communications network to which the said tariff applies.

3. A method according to claim 1 or 2, in which the step of distributing the tariff includes steps of communicating separately a formula for calculation of network usage charges , and coefficients for use in the said formula.

4. A method according to any one of the preceding claims, including a further step of distributing to the customer terminals a revised tariff.

5. A method according to claim 4 when dependent on claim 3, in which the step of distributing a revised tariff comprises communicating revised coefficients for use in the formula previously distributed to the customer terminals.

6. A method according to claim 4 or 5, including detecting loading of network resources and determining a revised tariff in dependence upon the results of the said step of detecting loading.

7. A method according to claim 6, in which the steps of detecting loading and determining a revised tariff are carried out automatically by a network management platform.

8. A method according to anyone of the preceding claims including communicating to a customer terminal data identifying a first predetermined communications channel, and at the customer terminal subsequently monitoring the said communications channel for communications relating to the said tariff.

9. A method according to claim 8, including communicating on the said first communications channel data identifying one or more further communications channels, and the customer terminal subsequently monitors in addition the or each further channel.

10. A method according to claim 9, including introducing a new communications channel and identifying the said new communications channel on a communications channel previously identified to the customer terminal depending on loading of the said previously identified communications channel.

11. A method according to any one of the preceding claims including communicating encrypted tariff data to the customer terminal, and decrypting the said tariff data within a secure module located at the customer terminal.

12. A method according to claim 11 including communicating different tariff data on a plurality of different communication channels and providing at a customer terminal a key specific to tariff data on one of the plurality of communication channels.

13. A method according to any one of the preceding claims, including operating a plurality of different services on the communications network,
communicating different tariffs for different respective services to the multiplicity of customer terminals, and selectively varying a respective tariff depending on an operational condition of the respective service.

14. A method of operating a communications network comprising:
operating a plurality of different services on the network;

communicating tariffs for the different services to a multiplicity of customer terminals via a common tariff distribution mechanism;

and selectively varying a respective tariff depending on an operational condition of a respective service.

15. A method according to any one of the preceding claims, including communicating different tariffs having different respective volatilties to different respective ones of the multiplicity of customer terminals.

16. A method of operating a communications network, including

calculating for each of a multiplicity of customers, using a selected one of a plurality of different tariffs, charges for the use of network resources by a respective customer terminal attached to the network,

measuring the loading of network resources, and

varying one or more of the plurality of different tariffs in dependence upon the loading of the network resources, and in which different ones of the plurality of different tariffs have different respective volatilities.

17. A method of operating a communications network in which at a point of access to the network a single blocking test only is applied to traffic entering the network .

18. A method of operating a communications network comprising:

a) communicating tariff data to a user terminal connected to the network;

b) calculating at the user terminal using the tariff data a charge for traffic communicated between the network and the terminal and making a payment;

c) sampling part only of the traffic communicated between users and the network and for the sampled traffic comparing any payments made by users and the payment due according to the tariff .

19. A method of operating a communications network comprising;

a) establishing contracts between network users and a network operator and storing user contract data;

b) sampling part only of the traffic to or from a user on the network;

c) comparing sampled traffic with traffic contracted for by the user; and

d) amending the user status when a discrepancy between the sampled parameters and the contracted parameters is detected.

20. A method according to claim 19, in which the step of establishing contracts between network users and the network operator includes making an advance payment for network usage.

21. A method according to claim 19 or 20, in which the step of amending the user status includes fining the user.

22. A method according to claim 19, in which in step (a) the user transfers a deposit to the network operator, which deposit is debited in step (d) when the discrepancy between the sampled parameters and the contracted parameters is detected.

23. A method according to any one of the preceding claims, in which the communications network is a network supporting a packet-based internetworking protocol.

24. A communications network arranged to operate by a method according to any one of the preceding claims.

25. A customer terminal adapted for use in a method according to any one of the preceding claims.

26. A customer terminal for use in a communications network, the customer terminal including;

a network interface which in use receives tariff information via a communications network;

a store programmed with tariff information received at the said interface;

a meter for measuring use by the customer terminal of the network to which the tariff applies; and

a processor connected to the said meter and to the store and arranged to calculate using the said tariff information a network usage charge.

27. A method of operating a communications network substantially as described with respect to the accompanying drawings and in the accompanying paper.

28. A communications network substantially as described with respect to the accompanying drawings and in the accompanying paper.

29.A method of operating a communications network comprising

a) at a customer terminal measuring network usage;

b) communicating network usage data from the customer terminal to the network operator; and

c) the network operator sampling part only of the traffic communicated between a customer terminal and the network and for the sampled traffic comparing the network usage with the network usage data from the customer terminal and thereby detecting any discrepancy.

30. A method according to any one of claims 1 to 10 including communicating encrypted tariff data to the customer terminal, and decrypting the said tariff data at the customer terminal.

31. A method of operating a communications network including;

distributing a tariff via the communications network to a multiplicity of customer terminals connected to the communications network,

measuring at a customer terminal use by the customer terminal of network resources; and

calculating, using the results of the said step of measuring together with the said tariff, a charge for use by the customer terminal of the network to which the tariff applies.

32. A method of operating a communications network, including automatically varying, depending on network loading as detected at a customer terminal, a tariff for network usage by a customer terminal.

33. A method according to any one of the preceding claims, including communicating different tariffs from a plurality of different service providers to a respective customer terminal, at the customer terminal selecting between the service providers, and receiving network services via the selected service provider.

34. A method according to any one of claims 19 to 20, in which the step of establishing contracts includes associating a traffic conditioning agreement (TCA) with a respective customer.

35. A method according to any one of the preceding claims, in which the tariff is distributed to customer terminals by multicasting.

36. A network arranged to operate by a method according to any one the claims 29 to 35.

Fig.1.

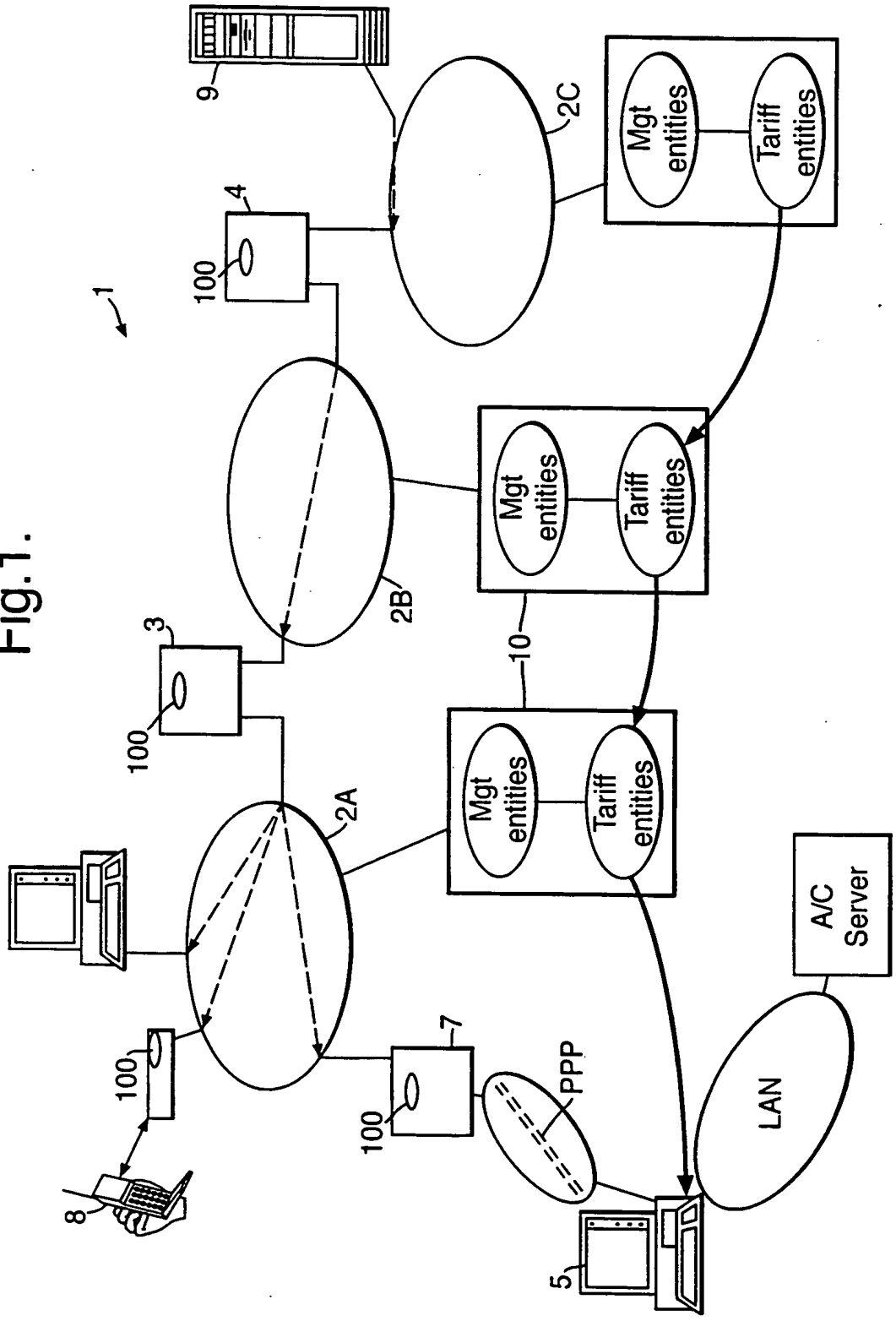

1
2A
2B
2C
3
4
5
7
8
9
10
100
Mgt entities
Tariff entities
A/C Server
LAN
PPP

Fig.2a.

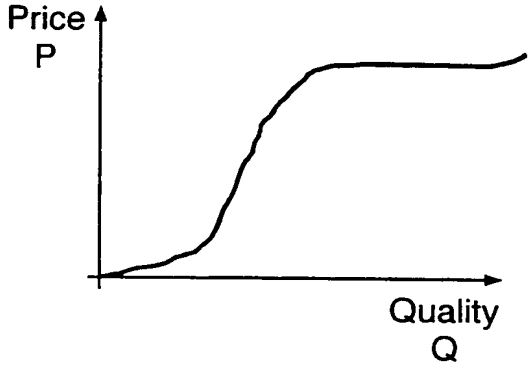


Fig.2b.

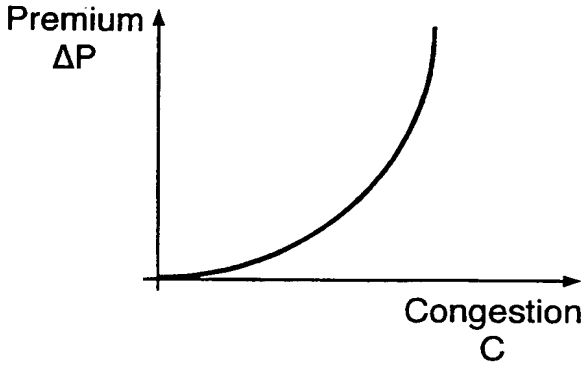


Fig.3.

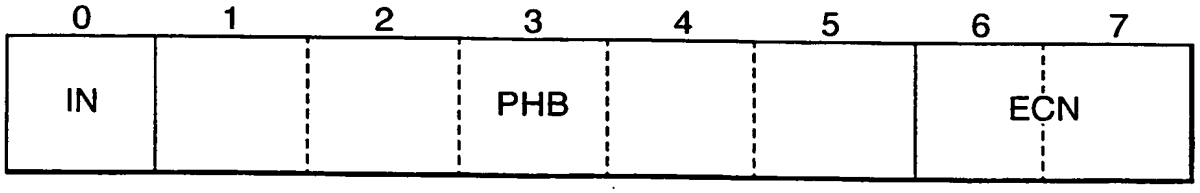


Fig.4a.

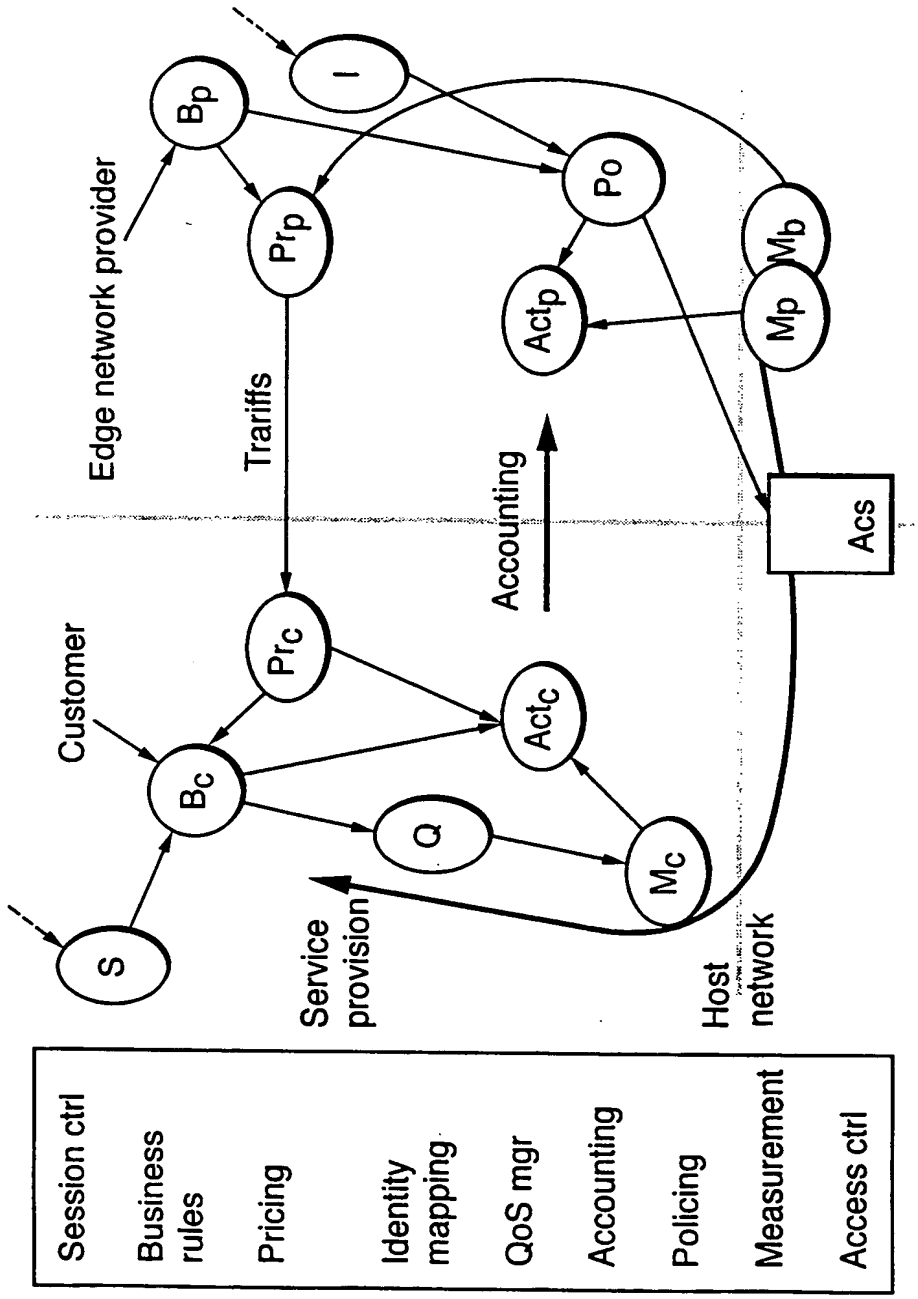

Edge network provider
Customer
Tariffs
Accounting
Service provision
Host network
Session ctrl
Business rules
Pricing
Identity mapping
QoS mgr
Accounting
Policing
Measurement
Access ctrl
I
Bp
Prp
Po
Actp
Mb
Mp
Acs
S
Bc
Prc
Actc
Q
Mc

Fig.4b.

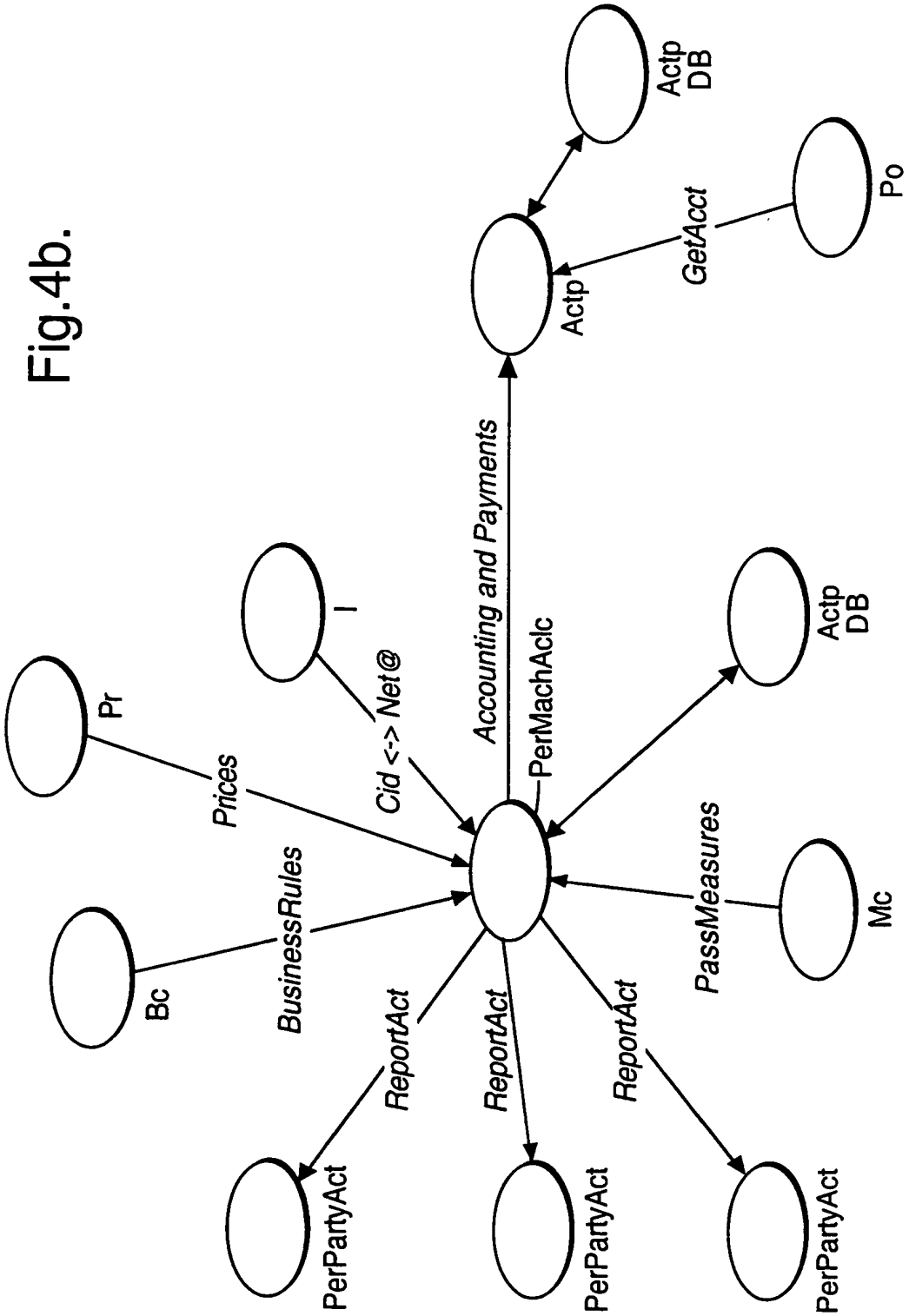

Actp DB
Po
GetAcct
Actp
Accounting and Payments
I
Cid <-> Net@
PerMachAclc
Actp DB
Pr
Prices
BusinessRules
PassMeasures
Mc
Bc
ReportAct
ReportAct
ReportAct
PerPartyAct
PerPartyAct
PerPartyAct

Fig.5a.

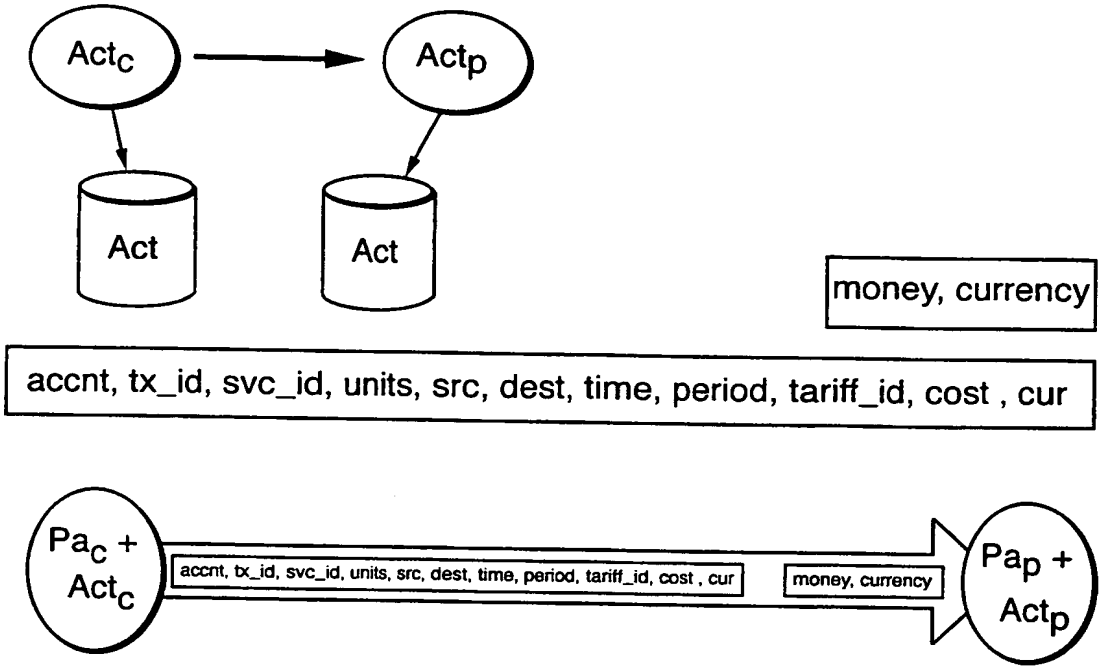

Act$_C$
Act$_P$
Act
Act
money, currency
accnt, tx_id, svc_id, units, src, dest, time, period, tariff_id, cost , cur
Pa$_C$ + Act$_C$
accnt, tx_id, svc_id, units, src, dest, time, period, tariff_id, cost , cur
money, currency
Pa$_P$ + Act$_P$

Fig.5b.

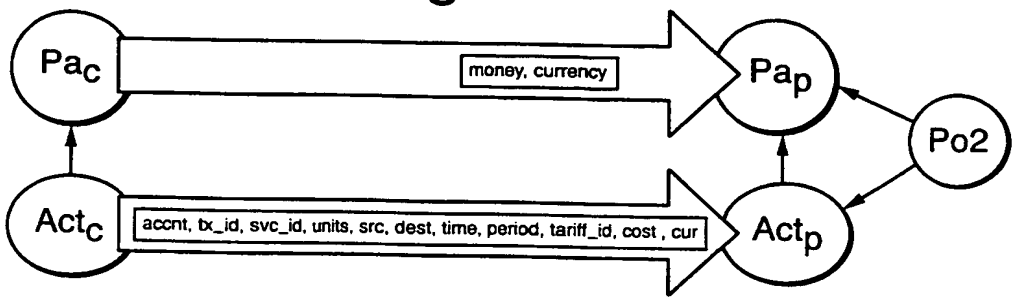

Pa$_C$
money, currency
Pa$_P$
Po2
Act$_C$
accnt, tx_id, svc_id, units, src, dest, time, period, tariff_id, cost , cur
Act$_P$

Fig.6.

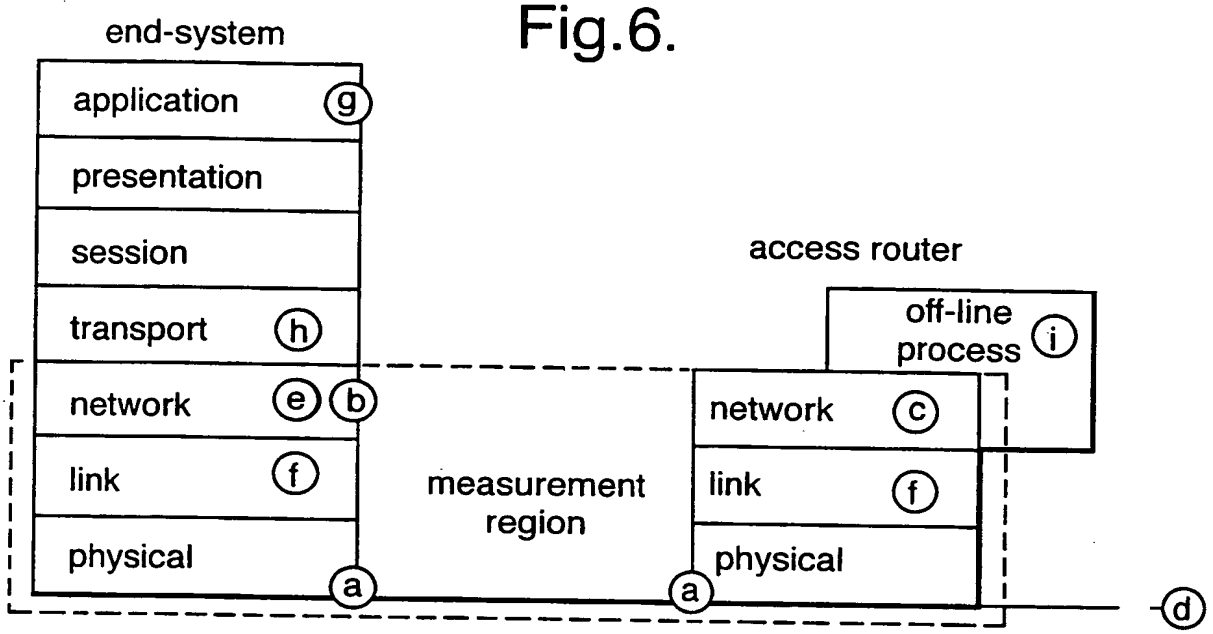

end-system
application
g
presentation
session
transport
h
network
e
b
link
f
physical
a
measurement region
access router
off-line process
i
network
c
link
f
physical
a
d

Fig.7.

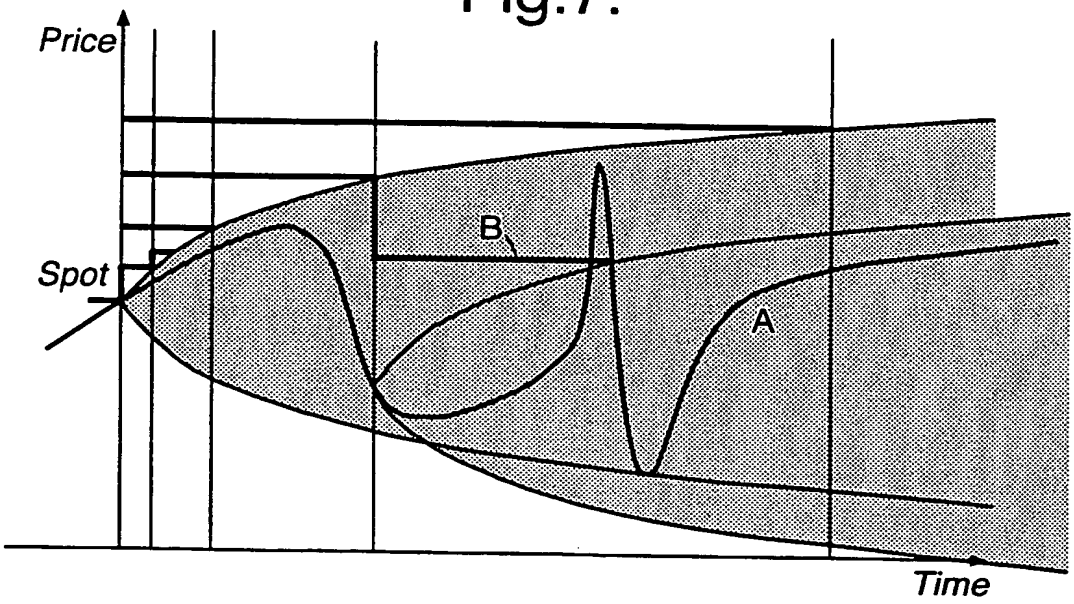

Price
Spot
B
A
Time

Fig.8a.

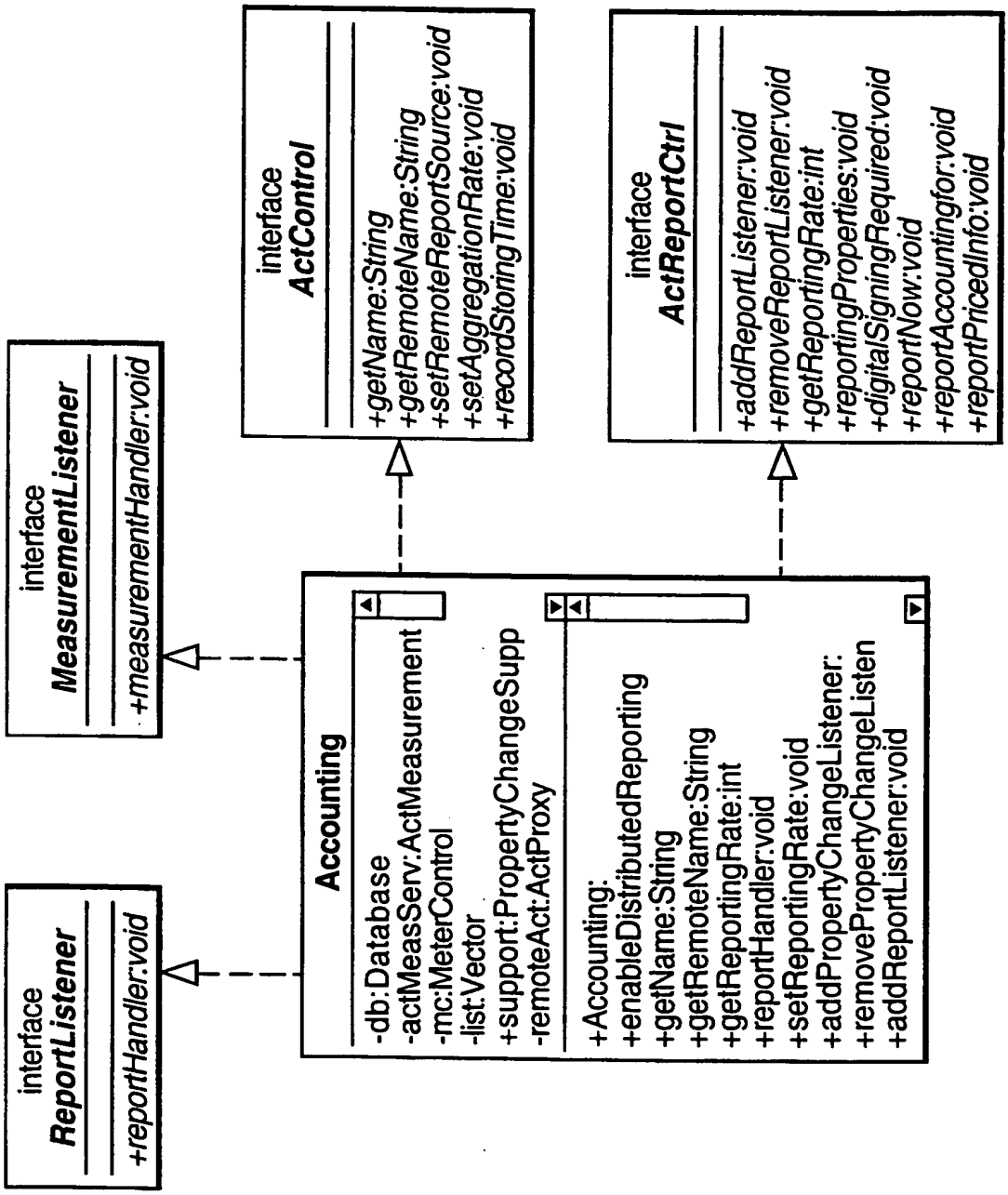

interface
ReportListener
+reportHandler:void
interface
MeasurementListener
+measurementHandler:void
interface
ActControl
+getName:String
+getRemoteName:String
+setRemoteReportSource:void
+setAggregationRate:void
+recordStoringTime:void
interface
ActReportCtrl
+addReportListener:void
+removeReportListener:void
+getReportingRate:int
+reportingProperties:void
+digitalSigningRequired:void
+reportNow:void
+reportAccountingfor:void
+reportPricedInfo:void
Accounting
-db:Database
-actMeasServ:ActMeasurement
-mc:MeterControl
-list:Vector
+support:PropertyChangeSupp
-remoteAct:ActProxy
+Accounting:
+enableDistributedReporting
+getName:String
+getRemoteName:String
+getReportingRate:int
+reportHandler:void
+setReportingRate:void
+addPropertyChangeListener:
+removePropertyChangeListen
+addReportListener:void

Fig.8b.

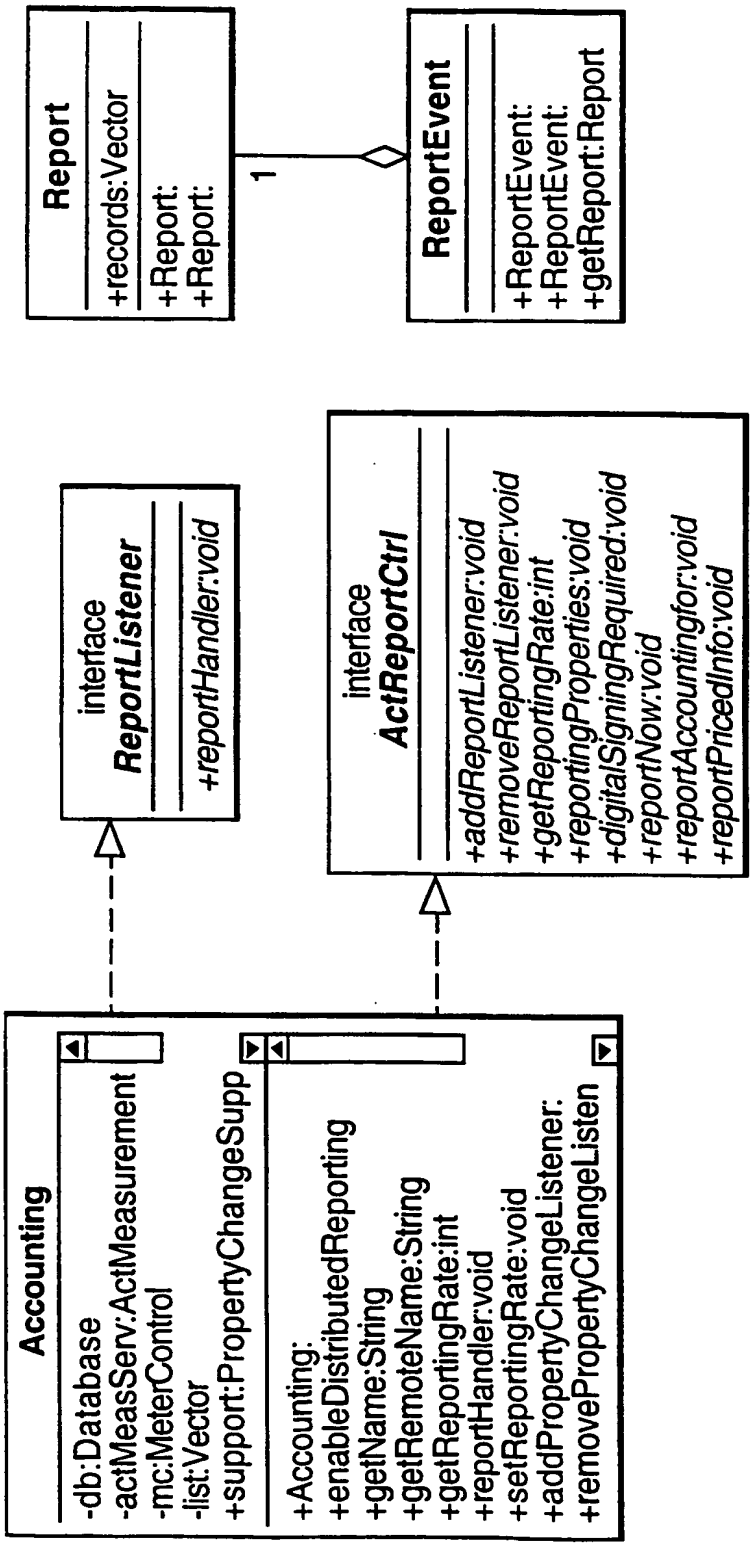

Report
+records:Vector
+Report:
+Report:
1
ReportEvent
+ReportEvent:
+ReportEvent:
+getReport:Report
interface
ReportListener
+reportHandler:void
interface
ActReportCtrl
+addReportListener:void
+removeReportListener:void
+getReportingRate:int
+reportingProperties:void
+digitalSigningRequired:void
+reportNow:void
+reportAccountingfor:void
+reportPricedInfo:void
Accounting
-db:Database
-actMeasServ:ActMeasurement
-mc:MeterControl
-list:Vector
+support:PropertyChangeSupp
+Accounting:
+enableDistributedReporting
+getName:String
+getRemoteName:String
+getReportingRate:int
+reportHandler:void
+setReportingRate:void
+addPropertyChangeListener:
+removePropertyChangeListen

Fig.8c.

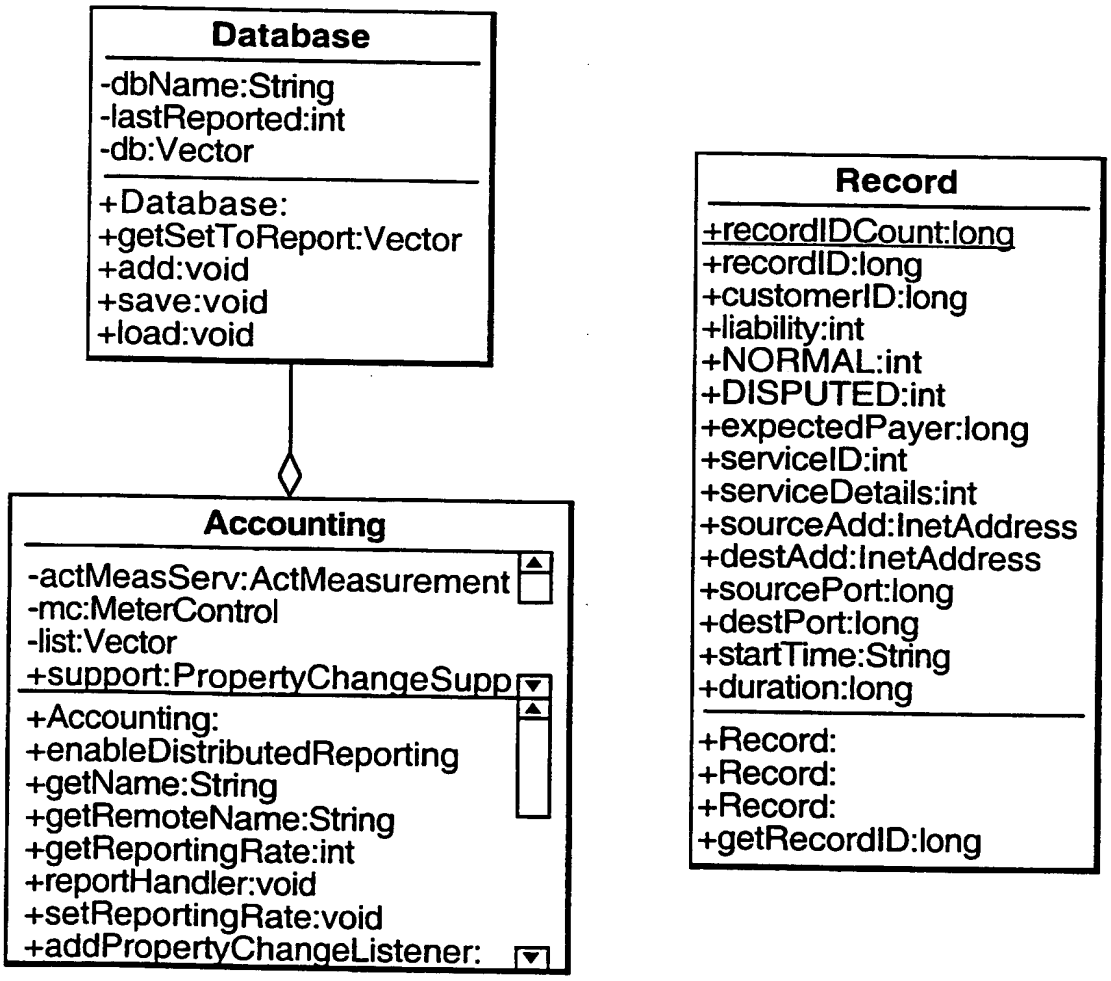

Database
-dbName:String
-lastReported:int
-db:Vector
+Database:
+getSetToReport:Vector
+add:void
+save:void
+load:void
Accounting
-actMeasServ:ActMeasurement
-mc:MeterControl
-list:Vector
+support:PropertyChangeSupp
+Accounting:
+enableDistributedReporting
+getName:String
+getRemoteName:String
+getReportingRate:int
+reportHandler:void
+setReportingRate:void
+addPropertyChangeListener:
Record
+recordIDCount:long
+recordID:long
+customerID:long
+liability:int
+NORMAL:int
+DISPUTED:int
+expectedPayer:long
+serviceID:int
+serviceDetails:int
+sourceAdd:InetAddress
+destAdd:InetAddress
+sourcePort:long
+destPort:long
+startTime:String
+duration:long
+Record:
+Record:
+Record:
+getRecordID:long

Fig.8d.

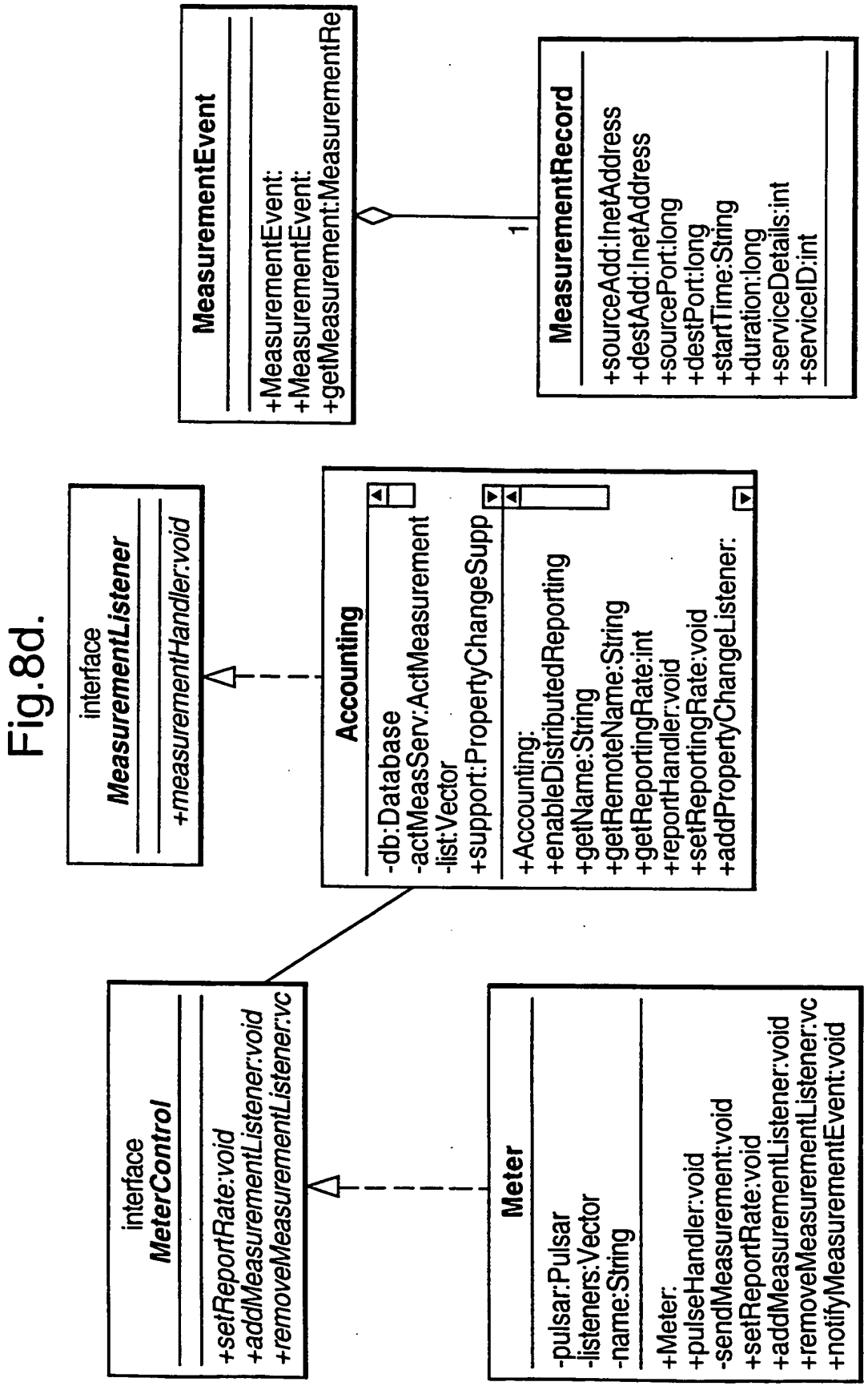

MeasurementEvent
+MeasurementEvent:
+MeasurementEvent:
+getMeasurement:MeasurementRe
1
MeasurementRecord
+sourceAdd:InetAddress
+destAdd:InetAddress
+sourcePort:long
+destPort:long
+startTime:String
+duration:long
+serviceDetails:int
+serviceID:int
interface
MeasurementListener
+measurementHandler:void
Accounting
-db:Database
-actMeasServ:ActMeasurement
-list:Vector
+support:PropertyChangeSupp
+Accounting:
+enableDistributedReporting
+getName:String
+getRemoteName:String
+getReportingRate:int
+reportHandler:void
+setReportingRate:void
+addPropertyChangeListener:
interface
MeterControl
+setReportRate:void
+addMeasurementListener:void
+removeMeasurementListener:vc
Meter
-pulsar:Pulsar
-listeners:Vector
-name:String
+Meter:
+pulseHandler:void
-sendMeasurement:void
+setReportRate:void
+addMeasurementListener:void
+removeMeasurementListener:vc
+notifyMeasurementEvent:void

Fig.8e.

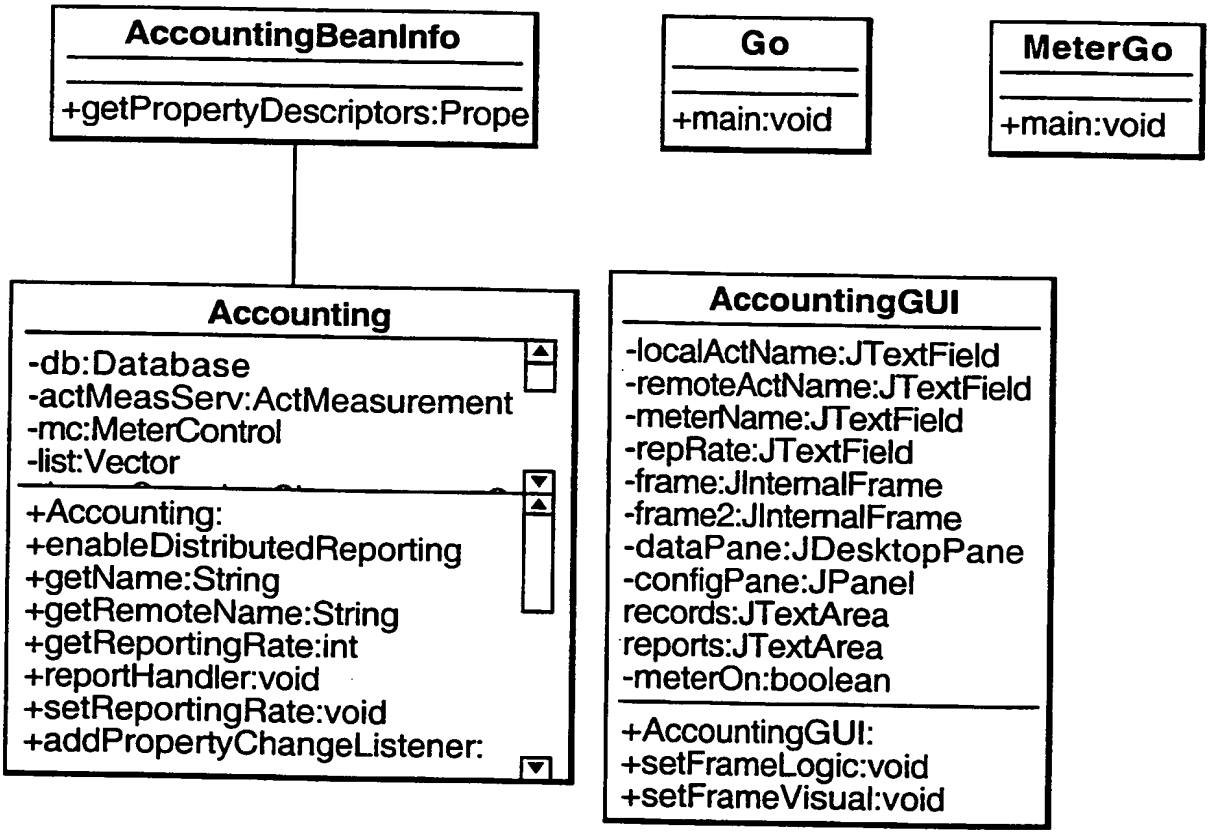

AccountingBeanInfo
+getPropertyDescriptors:Prope
Go
+main:void
MeterGo
+main:void
Accounting
-db:Database
-actMeasServ:ActMeasurement
-mc:MeterControl
-list:Vector
+Accounting:
+enableDistributedReporting
+getName:String
+getRemoteName:String
+getReportingRate:int
+reportHandler:void
+setReportingRate:void
+addPropertyChangeListener:
AccountingGUI
-localActName:JTextField
-remoteActName:JTextField
-meterName:JTextField
-repRate:JTextField
-frame:JInternalFrame
-frame2:JInternalFrame
-dataPane:JDesktopPane
-configPane:JPanel
records:JTextArea
reports:JTextArea
-meterOn:boolean
+AccountingGUI:
+setFrameLogic:void
+setFrameVisual:void

Fig.9.

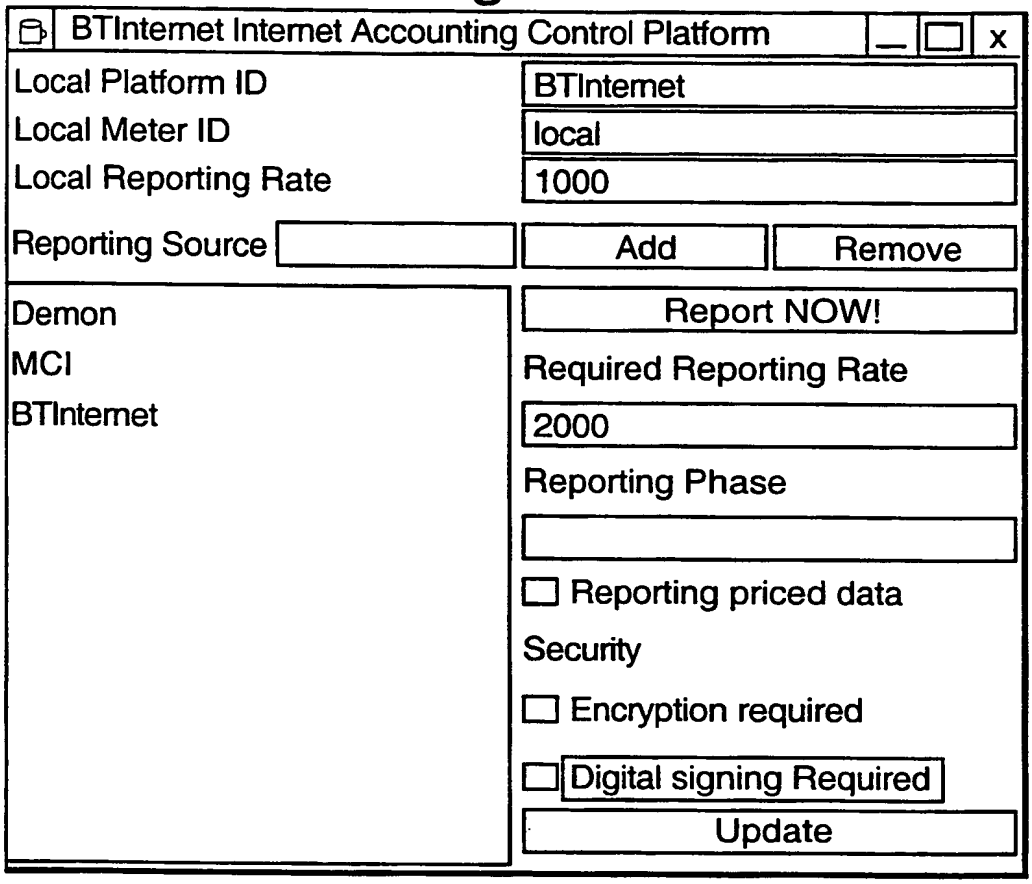

BTInternet Internet Accounting Control Platform
Local Platform ID
BTInternet
Local Meter ID
local
Local Reporting Rate
1000
Reporting Source
Add
Remove
Demon
MCI
BTInternet
Report NOW!
Required Reporting Rate
2000
Reporting Phase
Reporting priced data
Security
Encryption required
Digital signing Required
Update

Fig.10.

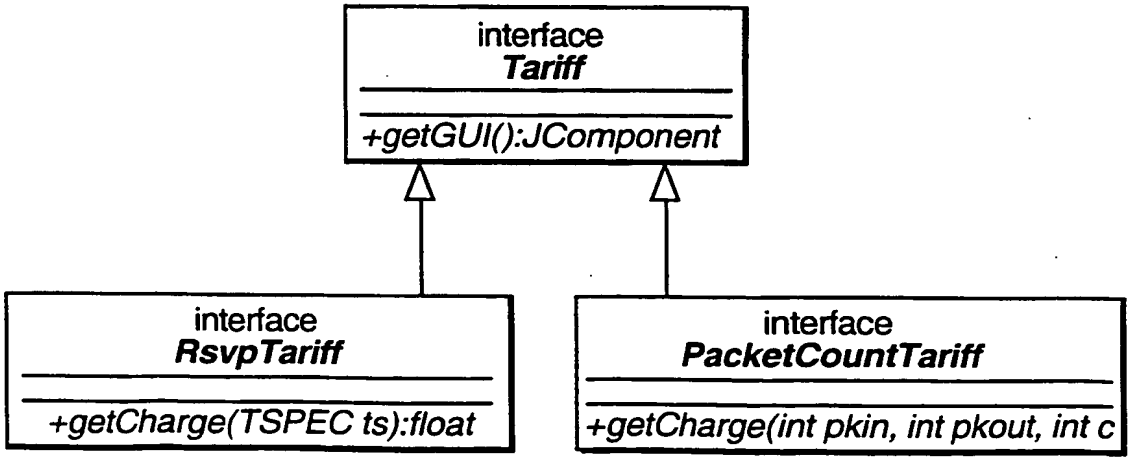

interface
Tariff
+getGUI():JComponent
interface
RsvpTariff
+getCharge(TSPEC ts):float
interface
PacketCountTariff
+getCharge(int pkin, int pkout, int c

Fig.11.

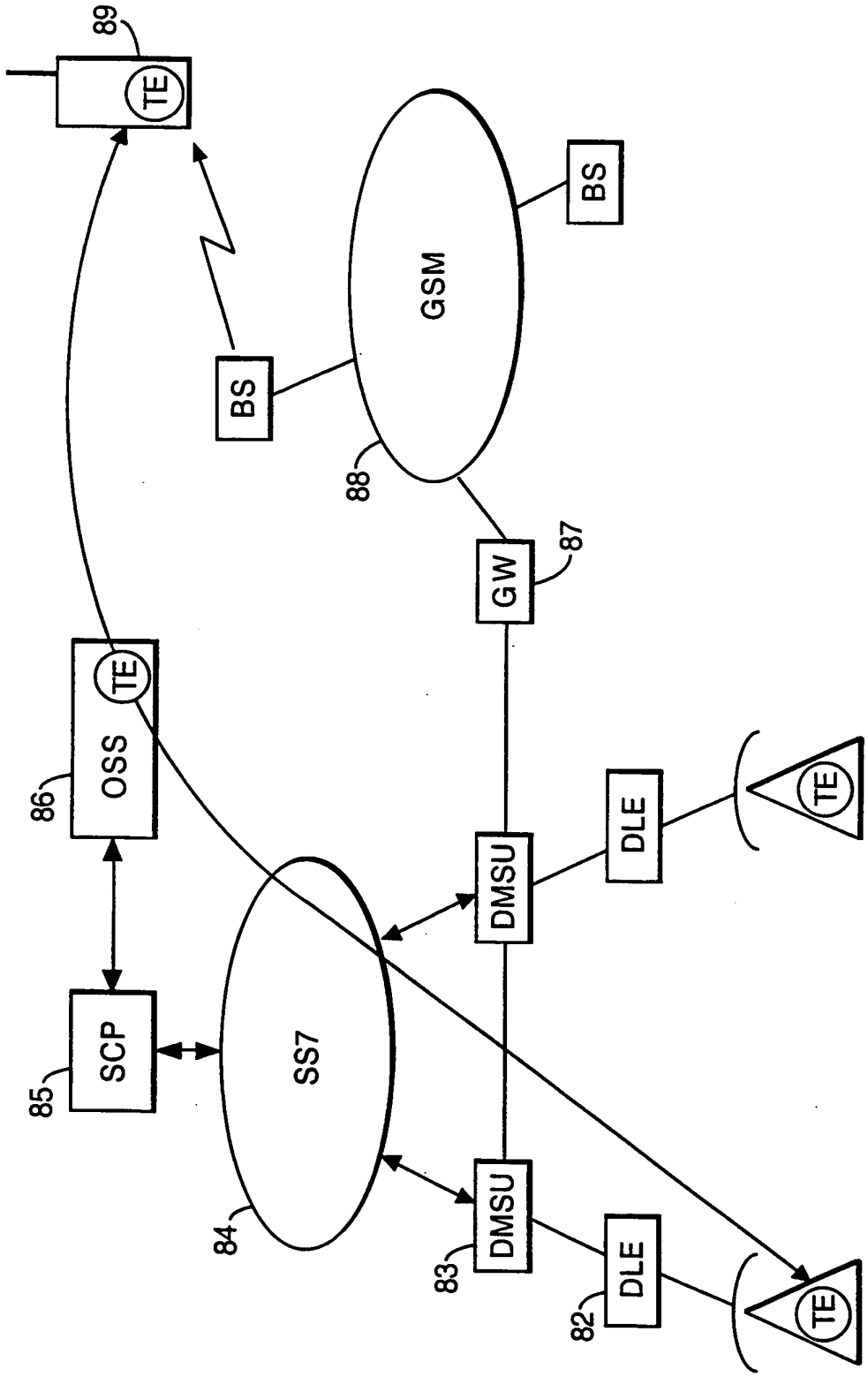
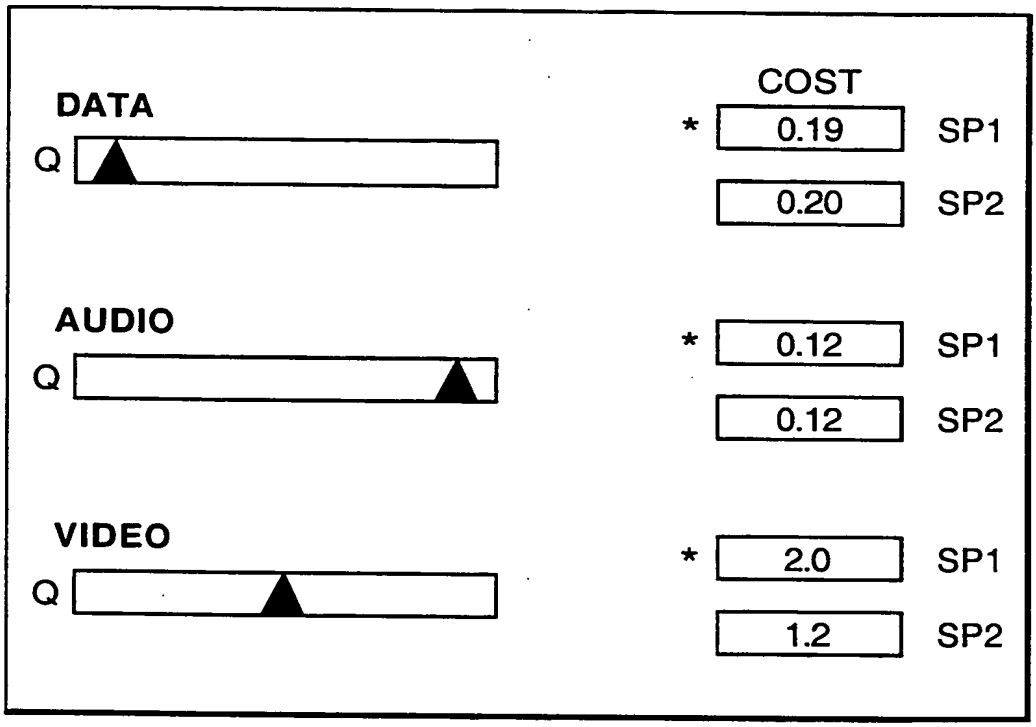

89
TE
BS
GSM
BS
88
87
GW
86
OSS
TE
DMSU
DLE
TE
SCP
85
SS7
84
DMSU
83
DLE
82
TE

Fig.12.


COST
DATA
Q
* 0.19 SP1
0.20 SP2
AUDIO
Q
* 0.12 SP1
0.12 SP2
VIDEO
Q
* 2.0 SP1
1.2 SP2